

THE
PHILOSOPHY
OF
NATURAL HISTORY,

BY
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OF EDINBURGH.

IN TWO VOLUMES.
V O L. I.

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TO
HIS ROYAL HIGHNESS
G E O R G E
PRINCE OF WALES,
THE
PHILOSOPHY OF NATURAL HISTORY
IS MOST HUMBLY DEDICATED,
BY HIS DEVOTED SERVANT,
WILLIAM SMELLIE.



P R E F A C E.

EVERY Preface, beside occasional or explanatory remarks, should contain not only the general design of the work, but the motives and circumstances which induced the author to write upon that particular subject. If this plan had been universally observed, prefaces would have exhibited a short, but a curious and useful, history both of literature and of authors. Influenced by this idea, I shall give a very compendious account of the origin, design, and progress of the following work.

About fifteen years ago, in a conversation with the late worthy, respectable,

table, and ingenious LORD KAMES, upon the too general neglect of natural knowledge, his Lordship suggested the idea of composing a book on the PHILOSOPHY OF NATURAL HISTORY. In a work of this kind, he proposed that the productions of Nature, which to us are almost infinite, should, instead of being treated of individually, be arranged under general heads; that, in each of these divisions, the known facts, as well as reasonings, should be collected and methodised in the form of regular discourses; that as few technical terms as possible should be employed; and that all the useful and amusing views arising from the different subjects should be exhibited in such a manner as to convey both pleasure and information.

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This task his Lordship was pleased to think me not altogether unqualified to attempt. The idea struck me. I thought that a work of this kind, if executed even with moderate abilities, might excite a taste for examining the various objects which every where solicit our attention. A habit of observation refines our feelings. It is a source of interesting amusement, prevents idle or vicious propensities, and exalts the mind to a love of virtue and of rational entertainment. I likewise reflected, that men of learning often betray an ignorance of the most common subjects of Natural History, which it is painful to remark.

I have been occasionally employed, since the period which I have mentioned, in collecting and digesting materials from the most authen-

tic sources. These materials I have interspersed with such observations, reflections, and reasonings, as occurred to me from considering the multifarious subjects of which I have ventured to treat. I knew that a deliberate perusal of the numerous writers from Aristotle downwards, would require a considerable portion of time. But the avocations of business, and the translating of a work so voluminous as the NATURAL HISTORY OF THE COUNT DE BUFFON, rendered my progress much slower than I wished. I now, however, with much diffidence, submit my labours to public opinion. An examination of the *Contents*, however, will convey a more clear idea of the nature of the work than a multiplicity of words. But I thought it proper to prefix a short account of the
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circumstances and motives which induced me to engage in an undertaking so extensive, and so difficult to perform with tolerable success.

With regard to the manner of writing, it is perhaps impossible for a North Briton, in a work of any extent, to avoid what are called Scotticisms. But I have endeavoured to be every where perspicuous, and to shun every sentiment or expression which might have a tendency to injure society, or to hurt the feelings of individuals.

Indulgent readers, though they must perceive errors and imperfections, will naturally make some allowance for the variety of research, and the labour of condensing so much matter into so small a compass. He is a bad author,

author, it has been said, who affords neither an aphorism nor a motto.

I cannot refrain from mentioning a circumstance which has often made me uneasy. The expectations of some friends were higher than I was conscious my abilities could reach.

Upon the whole, the general design of this publication is, to convey to the minds of youth, and of such as may have paid little attention to the study of Nature, a species of knowledge which it is not difficult to acquire. This knowledge will be a perpetual and inexhaustible source of manly pleasures; it will afford innocent and virtuous amusement, and will occupy agreeably the leisure or vacant hours of life.



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THE
PHILOSOPHY
OF
NATURAL HISTORY.

CHAPTER I.

Distinguishing characters of Animals, Plants, and Minerals—The Analogies between the plant and animal, arising from their structure and organs, their growth and nourishment, their dissemination and decay.

NATURAL Bodies, when viewed as they have a relation to man, are marked with characters so apparent, that they escape not the observation of the most unenlightened minds. In a system where all the constituent parts have a reciprocal dependence, and

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are connected by relations so subtle as to elude the perception of animals, such obvious characters were indispensable. Without them, neither the affairs of human life, nor the functions of the brute creation, could be carried on. Characters of this kind are accommodated to the apprehension of brutes and of vulgar men.

But, when the productions of nature are more closely examined; when they are scrutinized by the eye of philosophy, the number of their relations and differences is discovered to be almost infinite; and their shades of discrimination are often so delicate, that no sense can perceive them. Nothing, apparently, is more easy than to distinguish an animal from a plant; and yet the proper distinction has puzzled the most acute inquirers, and perhaps exceeds the limits of human capacity.

‘A plant,’ says Jungius, ‘is a *living*, but not a *sentient* body, which is fixed in a determined place, and grows, increases in size, and propagates its species *.’ In this definition living powers are ascribed to vegetables; but they are denied the faculty of sen-

* Raii Hist. Plant. p. 1.

sation



fation. Life, without some degree of sensation, is an incomprehensible idea. An animal limited to the sense of feeling alone, is the lowest conception we can form of life. Deprive this being of the only sense it possesses, and, though its figure should remain, we would instantly conclude it to be as inanimate as a stone. The life attributed to plants seems to be nothing more than an analogical deduction from their growth, nutrition, continuation of their species, and similar circumstances.

Ludwig defines vegetables to be ‘ Natural bodies, always endowed with the same form, but deprived of the power of local motion †.’ — Every branch of this definition is, with equal propriety, applicable to precious stones, salts, and some animals; and, therefore, requires no farther attention.

Sir Charles Linnaeus, in his *Fundamenta Botanica*, intends to discriminate the three kingdoms of nature in two lines. ‘ Stones,’ says he, ‘ *grow*; vegetables grow and *live*; animals grow, live, and *feel**.’ This is an assemblage of words, the meaning of which is entirely perverted. The idea of growth implies nutrition and expansion by the interven-

† Ludwig, *Phil. Bot.* p. 1.

* *Fund. Bot.* § 3.

tion of organs. The magnitude of stones may be augmented by an accretion of new matter. But this is not growth, or expansion of parts. The second definition, 'That vegetables grow and *live*,' is equally inaccurate. Instead of proving the life of plants, Linnaeus takes it for granted, and makes it the characteristic between vegetables and brute matter. The third, 'That animals grow, live, and *feel*,' is not less exceptionable. Growth, life, and mere sensation, convey the most ignoble notions of animated beings. From this definition, we would be led to imagine, that Linnaeus meant to describe the condition of a polypus or an oyster. All animals, it is true, grow, live, and feel: But these are only the passive properties of animals. The definition includes none of those instinctive, intellectual and active powers which exalt the animal above the vegetable, and so eminently distinguish the different tribes from each other.

These and many other abortive attempts have been made to ascertain the precise boundaries between the animal and vegetable. Definitions have been the perpetual aim of most writers on this subject. But definitions, when applied to natural objects, must always be vague and elusory. We know not the principle

ciple of animal life. We are equally ignorant of the essential cause of vegetable existence. It is in vain, therefore, to dream of being able to define what we never can know. We may, however, discover some qualities common to the animal as well as to the vegetable.

Sensation, motion, and structure of parts, give animals a more extensive range in their connection with external objects. A certain portion of intellect, joined to the vital principle, seem to be the most distinguishing properties of animals, and to constitute their essence or being. Animals will, determine, act, and have a communication with distant objects by their senses. They have the laws of nature, in some measure, at command. They protect themselves from injury by employing force, swiftness, address, and cunning. But vegetables remain fixed in the same place, and are subject to every thing that moves. Animals eat at intervals; their food requires time for digestion, and to answer the complicated purposes of secretion and nutrition. The structure of plants is more simple: They receive perpetual nourishment without injury. Animals search for and select particular kinds of food. But plants must receive whatever is brought to them

them by the different elements. Animals exist on the surface and in the interior parts of the earth, in the air, in water, in the bodies of men and other animals, in the internal parts of plants, and even in stones. But, if we except a few aquatics, plants are fixed to the earth by roots.

All animals, it has been affirmed, have a heart, or particular fountain for propelling and distributing their fluids to the different parts of their bodies: But caterpillars, and many other insects, have no such general receptacle.

The loco-motive faculty has been considered as peculiar to animals. But even this character is entirely suspicious. Oysters, sea-nettles, the gall-insects, and a variety of other animals, can hardly be said to enjoy the power of local motion. Many species remain for ever fixed to the rocks on which they are produced, and have no motion but that of extending or contracting their bodies. Besides, examples of different kinds of motion are discoverable in the vegetable kingdom. When the roots of a tree meet with a stone, or any other obstruction to their motion, in order to avoid it, they change their former direction. They turn from barren
to

to fertile earth, which indicates something analogous to a selection of food. Like the polypus, plants, when confined in a house, uniformly bend toward the window or aperture through which the rays of light are introduced.

The sensitive plant possesses the faculty of motion in an eminent degree. The slightest touch makes its leaves suddenly shrink, and, together with the branch, bend down toward the earth. But the moving plant, or *hedyfarum movens*, of which there are specimens in the botanic garden of Edinburgh, furnishes the most astonishing example of vegetable motion. It is a native of the East Indies. Its movements are not excited by the contact of external bodies, but solely by the influence of the sun's rays. The motions of this plant are confined to the leaves, which are supported by long flexible foot-stalks. When the sun shines, the leaves move briskly in every direction. Their general motion, however, is upward and downward: But they not unfrequently turn almost round; and then their foot-stalks are evidently twisted. These motions go on incessantly as long as the heat of the sun continues; But they cease during the night, and when the weather

ther is cold and cloudy. Our wonder is excited by the rapidity and constancy of the movements peculiar to this plant. The frequency, however, of similar motions in other plants, renders it probable that the leaves of all vegetables move, or are agitated by the rays of the sun, though many of these movements are too slow for our perception.

The American plant called *dionaea muscipula*, or *Venus's fly-trap*, affords another instance of rapid vegetable motion. Its leaves are jointed, and furnished with two rows of strong prickles. Their surfaces are covered with a number of minute glands, which secrete a sweet liquor, and allure the approach of flies. When these parts are touched by the legs of a fly, the two lobes of the leaf instantly rise up, the rows of prickles lock themselves fast together, and squeeze the unwary animal to death. If a straw or a pin be introduced between the lobes, the same motions are excited.

When a seed is sown in a reversed position, the young root turns downward to enter the earth, and the stem bends upward into the air. Confine a young stem to an inclined position, and its extremity will soon assume its former perpendicular direction. Twist the
branches

branches of any tree in such a manner that the inferior surfaces of the leaves are turned toward the sky, and you will, in a short time, perceive that all these leaves resume their original position. These motions are performed sooner or later, in proportion to the degree of heat, and the flexibility of the leaves. Many leaves, as those of the mallow, follow the course of the sun. In the morning, their superior surfaces are presented to the east; at noon, they regard the south; and, when the sun sets, they are directed to the west. During the night, or in rainy weather, these leaves are horizontal; and their inferior surfaces are turned toward the earth.

What has been denominated the Sleep of Plants, affords an instance of another species of vegetable motion. The leaves of many plants fold up during the night; but, at the approach of the sun, they expand with renewed vigour. The common appearances of most vegetables are so changed in the night, that it is difficult to recognise the different kinds, even by the assistance of light.

The modes of folding in the leaves, or of sleeping, are extremely various. But it is worthy of remark, that they all dispose themselves

selves so as to give the best protection to the young stems, flowers, buds, or fruit. The leaves of the tamarind-tree contract round the tender fruit, and protect it from the nocturnal cold. The cassia or senna, the glycine, and many of the papilionaceous plants, contract their leaves in a similar manner. The leaves of the chickweed, of the asclepias, atriplex, &c. are disposed in opposite pairs. During the night, they rise perpendicularly, and join so close at the top, that they conceal the flowers. The leaves of the sida or althaea Theophrasti, of the ayenia, and oenothera, are placed alternately. Though horizontal, or even depending, during the day, at the approach of night they rise, embrace the stem, and protect the tender flowers. The leaves of the solanum, or nightshade, are horizontal during the day; but, in the night, they rise and cover the flowers. The Egyptian vetch erects its leaves during the night, in such a manner that each pair seem to be one leaf only. The leaves of the white lupine, in the state of sleep, hang down, and protect the young buds from being injured by the nocturnal air.

These and similar motions are not peculiar to the leaves of plants. The flowers have
also

also the power of moving. During the night, many of them are inclosed in their calixes. Some flowers, as those of the German spurge, *geranium striatum*, and common whitlow grafs, when asleep, hang their mouths toward the earth, to prevent the noxious effects of rain or dew.

The cause of those movements which constitute the sleep of plants, has been ascribed to the presence or absence of the sun's rays. In some of the examples I have given, the motions produced are evidently excited by heat. But plants kept in a hot-house, where an equal degree of heat is preserved both day and night, fail not to contract their leaves, or to sleep, in the same manner as when they are exposed to the open air. This fact evinces, that the sleep of plants is rather owing to a peculiar law, than to a quicker or slower motion of the juices.

A stomach and brain have been reckoned essential characteristics of the animal; and plants are said to possess nothing analogous to these organs. But the polypus has no stomach; or rather, like vegetables, its whole body may be considered as a stomach. Its internal cavity contains no viscera; and, when this animal is turned outside in, it still
continues

continues to live, and to digest its food, in the same manner as if it had received no injury. The mode by which plants are nourished is extremely analogous. They imbibe food by the roots, the trunk, the branches, the leaves, and the flowers. Instead, therefore, of having no stomach, their whole structure is stomach. With regard to the brain, the polypus, and many other insects, are deprived of that organ. Hence neither stomach nor brain are essential characters which discriminate the animal from the vegetable.

But all animals are endowed with sensation, or at least with irritability, which last has been considered as a distinctive character of animal life. Sensation implies a distinct perception of pleasure and pain. We infer the existence of sensation in organized bodies, when we perceive that they have organs similar to our own, or when they act, in certain circumstances, in the same manner as we act. If an organized being has eyes, ears, and a nose, we naturally conclude that it enjoys the same sensations as these organs convey to us. If we see another being, whose structure exhibits nothing analogous to our organs of sensation, contracting with rapidity when touched, directing its body uniformly to the light, seizing

seizing small insects with *tentacula*, or a kind of arms, and conveying them into an aperture placed at its anterior end, we hesitate not to pronounce that it is animated. Cut off its arms, deprive it of the faculty of contracting and extending its body, the nature of this being will not be changed ; but we will be unable to determine whether it possesses any portion of life. This is nearly the condition of the small sections of a polypus, before their heads begin to grow. The wheel-animal, the eels in blighted wheat, and the snails recorded in the Philosophical Transactions, afford instances of every appearance of sensation, or even of irritability, being suspended, not for months, but for several years, and yet the life of these animals is not extinguished ; for they uniformly revive upon a proper application of moisture.

These and similar facts show, that we are entirely ignorant of the essence and properties of life. What life really is, seems too subtle for our understanding to conceive, or our senses to discern. If we have no other criterions to distinguish life, than motion, sensation, and irritability, the animals just mentioned continued for years in a state which every man would pronounce to have been perfectly

perfectly dead. It is possible, therefore, that life may exist in many bodies which are commonly thought to be as inanimate as stones. Hence it would be rash to exclude plants from every species of sensation. The degrees of sensation decrease imperceptibly from man to the sea-nettle, gall-insects, and what are called the most imperfect animals. Every vegetable, as well as the sensitive plant, shrinks when wounded. But, in most of them, the motion is too slow for our perception. When trees grow near a ditch, the roots which proceed in a direction that would necessarily bring them into the open air, instead of continuing this noxious progress, sink below the level of the ditch, then shoot across, and regain the soil on the opposite side. When a root is uncovered, without exposing it to much heat, and a wet sponge is placed near it, but in a different direction from that in which the root is proceeding, in a short time the root turns towards the sponge. In this manner the direction of the roots may be varied at pleasure. All plants make the strongest efforts, by inclining, turning, and even twisting their stems and branches, to escape from darkness and shade, and to procure the influences of the sun. Place a wet
sponge

sponge under the leaves of a tree, they soon bend downward, and endeavour to apply their inferior surfaces to the sponge. If a vessel of water be placed within six inches of a growing cucumber, in twenty-four hours the cucumber alters the direction of its branches, bends either to the right or left, and never stops till it comes into contact with the water. When a pole is placed at a considerable distance from an unsupported vine, the branches of which are proceeding in a contrary direction from that of the pole, in a short time, it alters its course, and stops not till it clings around the pole.

Facts of this kind excite our wonder; but they by no means prove that vegetables live, or that they are endowed with sensation, which implies a distinct perception of pleasure and pain.

There is an inferior species of sensation, which is distinguished by the term *irritability*. This term denotes that power by which muscular fibres, even after they are detached from the body, contract upon the application of any stimulating substance, whether solid or fluid. The heart of a frog, when pricked with the point of a pin, continues to beat, or to contract and dilate, for several
hours

hours after it has been cut out of the animal's body. The heart of a viper, or of a turtle, beats distinctly from twenty to thirty hours after the death of these animals. The peristaltic motion of the intestines is produced by their irritability. When the intestines of a dog, or any other quadruped, are suddenly cut into different portions, all these portions crawl about like worms, and contract upon the slightest touch. Though irritability be unquestionably a vital principle, yet it is equally certain, that muscular fibres, when separated from the body to which they belong, have no distinct perception of pleasure or pain. Their regular contraction and dilatation are evident symptoms of life, which, in many cases, may lead us to attribute living powers to substances that enjoy neither life nor sensation. Hence, though all plants were irritable, this circumstance would not prove that they are possessed of life. The contraction and dilatation of the sensitive plants, and the various motions of the leaves, branches, flowers, and roots of vegetables formerly mentioned, seem to indicate that most plants are endowed with irritability. Perhaps all vegetables have more or less of this quality. The heart, intestines, and diaphragm,

phragm, are the most irritable parts of animal bodies : And, to discover whether this quality resides in all plants, experiments should be made chiefly on their leaves, flowers, buds, and the tender fibres of the roots.

From this narration of facts, it appears, that plants make a very near approach to animals ; and that this similitude, as well as the difficulty of fixing the precise boundaries by which these two great kingdoms of nature are limited, are direct consequences of the organization of vegetables. It is owing to their organic structure alone, that plants and animals are capable of affording reciprocal nourishment to each other. This organic structure, though greatly diversified in the different species of animals and vegetables, evinces that Nature, in the formation of both, has acted upon the same general plan. May we not presume, therefore, as plants as well as animals are composed of a regular system of organs, that the vegetable part of the creation is not entirely deprived of every quality which we are apt to think peculiar to animated beings ? I mean not to insinuate, that plants can perceive pleasure or pain. But, as many of their motions and affections cannot

be explained upon any principle of mechanism, I am inclined to think, that they originate from the power of irritability, which, though it implies not the perception of pleasure and pain, is the principle that regulates all the vital or involuntary motions of animals. To ascertain this point, would require a set of very nice experiments. I shall mention one, which might be performed with tolerable ease. It was formerly remarked, that plants kept in a hot-house, where the degree of heat is uniform, never fail to sleep during the night. This is direct evidence, that heat alone is not the cause of their vigilance. But they are deprived of light. Let, therefore, a strong artificial light, without increasing the heat, be thrown upon them. If, notwithstanding this light, the plants are not roused, but continue to sleep as usual, then it may be presumed that their organs, like those of animals, are not only irritable, but require the reparation of some invigorating influence which they have lost while awake, by the agitations of the air and the sun's rays, by the act of growing, or by some other latent cause.

It is almost unnecessary to mark the distinction between vegetables and minerals. The
transition

transition from the animal to the plant is effected by shades so imperceptible, as to elude the most acute observers. But, between the plant and the mineral, there is a vast chasm in the chain of being, which may be the source of great discoveries. In bodies purely mineral, not a vestige of organization can be discovered. The fibrous structure of the asbestos has been regarded as an approach toward organization, and as the link which connects the mineral to the vegetable kingdom. But this is one of those strained analogies which are too often employed by theoretical writers. Though the asbestos is composed of a kind of threads or fibres, these fibres are not tubular; neither are they interwoven, like that regular tissue or fabric which so remarkably distinguishes organized from brute matter. Of course, the magnitude of the asbestos can only be increased by the apposition of new matter, and not by any developement or expansion of parts. But tho' in the mineral kingdom, Nature ceases to organize, she continues to arrange.

The regular configuration of salts, crystals, and other precious stones, has been considered by some authors as the result of an organic process. But the uniform figure of salts

and crystals may be the effect of certain laws of attraction peculiar to each species. None of these particles can be regarded as a germ or bud. They are only the elements or constituent parts, which, when applied to each other, form a whole. They never expand or grow, like the embryos of animals or plants. They remain for ever in the same state without diminution or increase, except when separated by force, or magnified by an accumulation of fresh matter. The chryselline juice is not assimilated by vessels: It is prepared by a chymical operation of Nature. The bodies of plants and animals are machines, exceedingly elaborate, and more or less complicated. These machines, by means of different organs, have the power of converting other animals and vegetables into their own substance. By this assimilation, all the dimensions are increased; and their various parts uniformly preserve the same proportions with regard to each other, and continue to perform their respective functions. Besides, organized bodies not only multiply their species, but some of them possess the power of reproducing such parts as are forcibly abstracted from them.

In

In these and many other qualities common to the animal and vegetable, there is not the smallest analogy to be found in the mineral kingdom. Between the most regular fossils, as salts and crystals, and the most imperfect animal or vegetable, the distance is immense. Figured fossils are not more organized than a column or portico. In the formation of the former, Nature, in that of the latter, man, is the artist. When no similarity is to be discovered in those fossils which are nearly uniform in their configuration, we are not to expect it in the more loose and irregular parts of brute matter. Here, Nature, regardless of symmetry, conjoins heterogeneous materials, of which she composes irregular masses. Many stones, flints, and other concretions, afford examples of this kind. More art, it must be acknowledged, appears in the formation of metals: But their structure exhibits no vestiges of organization.

A N A L O G I E S.

HAVING shown the extreme difficulty of fixing the boundaries which separate the animal from the vegetable kind, I proceed to the more pleasing task of enumerating some of those beautiful analogies which subsist between

tween them. To render this subject the more agreeable and instructive, instead of bringing together an unconnected mass, I shall trace the analogies between the animal and plant, under the arrangement of *Structure and Organs, Growth and Nourishment, Dissemination and Decay.*

I. STRUCTURE AND ORGANS.

IN all organized bodies, a similarity of structure seems to be unavoidable. The bodies of men and quadrupeds consist of a series of connected bones, which run from the head to the rump. This series is known by the name of the *back-bone*, from each side of which, a number of arched bones proceed. Some of these join the breast-bone by means of cartilages, and form a vaulted cavity, which contains and defends the heart, and other viscera proper to the chest. The bones of the pelvis, and of the four extremities, are joined to the back-bones by articulations and membranes. By the same contrivance, the cranium is fixed to the upper end of the back-bones. Into different processes and portions of all these bones, a great number of muscles, or bundles of fleshy fibres, are inserted. These muscles are the instruments which give
rise

rife to all the varieties of animal motion. The bones of the head, or cranium, contain the brain and cerebellum, a prolongation of which runs through the whole extent of the canal in the back-bone, and is known by the term *spinal marrow*. From the brain and spinal marrow proceed all the nerves, or instruments of fenfation. Thefe nerves, the ramifications of which are infinitely various and minute, are diftributed upon the heart, lungs, blood-veffels, bowels, and mufcles, till they terminate on the fkin, or external covering of the body. The heart is the fountain or general receptacle of the blood. The contraction of the heart propels the blood through the arteries, which are likewise diftributed, by numerous and complicated ramifications, over every part of the body, and terminate in the veins, which again collect the whole arterial blood into one cavity, and re-convey it to the heart. This circulatory procefs goes on during life.

Befide the organs already mentioned, there are others, termed *fecretory*, becaufe they feparate peculiar fluids from the general mafs of circulating blood. The ftomach and inteflines are furnifhed with a vaft number of fmall tubes, called *laâleal ducts*, which feparate and
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absorb the nutritious parts of the aliment, and reject all the grosser and useless particles. These ducts, after innumerable communications with each other, unite into one large tube, distinguished by the name of the *thoracic duct*, which is the general reservoir of the chyle, or secreted liquor. This chyle, which is a mild fluid, passes from the thoracic duct to the subclavian vein; and by this vein it is conveyed to the heart, where it mingles with the blood, and is circulated through the body, for the nourishment of its different parts. It is of no moment, for our present purpose, to be more particular, especially as this subject will be afterwards more fully handled. I shall therefore just mention, that there are particular organs or glands for secreting various fluids, which are necessary to the existence of the larger animals, as the kidneys for the secretion of urine; the liver for the secretion of gall; the stomach for the secretion of the gastric juices; the salivary glands for the secretion of saliva, &c.

From this sketch of the structure of man and of quadrupeds, very little attention is necessary to perceive, that Nature pursues a similar plan in the formation of birds and fishes.

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In that numerous class of animals distinguished by the name of *insects*, there is a great variety of form and structure. In many of these, Nature seems to depart from her general mode of operation. But upon a more accurate examination, this seeming departure will appear to be only an extension of that universal plan which she observes in the formation of all animated beings. Some insects, the lobster, and all the crustaceous and shell animals, have their bones on the outside of their bodies. To these bones the muscles and other instruments of motion are attached. Many species have no bones; but their bodies consist of a succession of rings incased into each other. By contracting and dilating these rings, all the movements of this kind are performed. The head, in some species, changes its form every moment. It contracts or dilates, appears or disappears, at the pleasure of the animal. These motions are permitted by the flexibility of the membranes, or coverings of the head. In other species, the form of the head is permanent, owing to the hardness of the coverings, which are scaley or crustaceous, and approaches nearer to that of the more perfect animals.

Many

Many insects are destitute of particular organs. Some want eyes, ears, brain, and nostrils. Others have an acute sense of smelling, though we know not the form or situation of the organ. The inferior species of insects have no internal lungs, but receive air by lateral pores, and sometimes by long tubes, or tracheae, which protrude from different parts of the body. Many insects have no heart, or general reservoir for the reception and propulsion of the blood. But we discover by the microscope, that their blood circulates by the pulsation of arteries, and that their different fluids are secreted by glands. In a word, Nature, in the structure and functions of animals, descends, by degrees almost imperceptible, from man to the polypus, a being which, ever since its oeconomy and properties were discovered by M. Trembley, has continued to astonish both philosophers and naturalists. The structure of the polypus, which inhabits fresh water pools and ditches, is extremely simple. Its body consists of a single tube, with long *tentacula*, or arms, at one extremity, by which it seizes small worms, and conveys them to its mouth. It has no proper head, heart, stomach, or intestines of any kind. This simplicity of structure

ture gives rise to an equal simplicity in the oeconomy and functions of the animal. The polypus, though it has not the distinction of sex, is extremely prolific. When about to multiply, a small protuberance or bud appears on the surface of its body. This bud gradually swells and extends. It includes not a young polypus, but is the real animal in miniature, united to the mother as a sucker to the parent-tree. The food taken by the mother passes into the young by means of a communicating aperture. When the shooting polypus has acquired a certain growth, this aperture gradually closes, and the young drops off, to multiply its species in the same manner. As every part of a polypus is capable of sending off shoots, it often happens, that the young, before parting from the mother, begin to shoot; and the parent-animal carries several generations on her own body. There is another singularity in the history of the polypus. When cut to pieces in every direction fancy can suggest, it not only continues to exist, but each section soon becomes an animal of the same kind. What is still more surprising, when inverted as a man inverts the finger of a glove, the polypus seems to have suffered no material injury; for it soon

soon begins to take food, and to perform every other natural function. Here we have a wonderful instance of animal ductility. No division, however minute, can deprive these worms of life. What infallibly destroys other animals, serves only, in the polypus, to multiply the number of individuals. M. Trembley, in the course of his experiments, discovered, that different portions of one polypus could be ingrafted on another. Two transverse sections brought into contact quickly unite, and form one animal, though each section belongs to a different species. The head of one species may be ingrafted on the body of another. When a polypus is introduced by the tail into another's body, the two heads unite, and form one individual. Pursuing these strange operations, M. Trembley gave scope to his fancy, and, by repeatedly splitting the head and part of the body, formed hydras more complicated than ever struck the imagination of the most romantic fabulists.

This short account of the general structure of animals was a necessary preparation for perceiving more clearly their connection with the vegetable kingdom.

The structure of plants, like that of animals, consists of a series of vessels disposed
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in a regular order. These vessels are destined to perform the different functions necessary to the nourishment, growth, and dissemination of the plant. In trees, and most of the larger vegetables, three distinct parts are to be observed; the bark, the wood, and the pith. The bark likewise consists of three parts; the skin, the body, and the *liber*, or inner circle; which last, about the end of autumn, assumes the same texture and firmness with the wood. The substance of the bark is composed of a number of longitudinal sap and air vessels, which have the appearance of fine threads, running from the root to the trunk and branches. Beside these vessels, the bark is furnished with a parenchymatous or pulpy substance, in which there are a vast variety of *folliculi*, or small bladders. The bark is connected to the wood by transverse insertions of the parenchyma.

The wood consists of two distinct substances; the one is dense, and compact, and constitutes what is termed the *ligneous body*; the other is porous, moist, and pulpy, and is therefore called the *parenchymatous* part of the wood. A portion of wood is placed alternately between a similar portion of parenchyma. These alternate portions proceed
from

from the edges of the pith, as *radii* from the center of a circle, widening proportionally as they approach the circumference. Both of them, however, like the bark, are furnished with numberless sap and air vessels.

The pith or heart is bounded on all sides by the wood, and is composed of the same materials: It is nothing but a vast congeries of air and sap vessels, interwoven with the parenchyma and bladders, not unlike the tissue of gauze or lace. This texture is common to every part of the trunk, being only more close and compact in the bark and wood than in the pith. It is well known, that the pith of plants diminishes in proportion to their age. The reason is obvious: Every year the ring of vessels, which lies contiguous to the wood, dries, condenses, and becomes wood.

The leaves of vegetables consist of a fine skin, which incloses the parenchyma or pulp. This skin, like that of animals, is an organic body, furnished with an immense number of parenchymatous and ligneous fibres, and interwoven in a manner precisely similar to that of the trunk and branches. When the skin is removed, the pulp appears, and is every where interspersed with small cylindrical

drical fibres, wound up into minute bladders. A large nerve runs along the middle of every leaf, and continually sends off branches, which gradually decrease in magnitude, till they reach the edge or disc. This principal nerve is a collection of small tubes, which, at proper distances, go off, and are distributed over the leaf in a manner precisely similar to the distribution of the nerves over the human body.

With regard to flowers and fruits, their general texture is the same with that of the parts already described, differing only in various proportions of the ligneous vessels and parenchymatous or pulpy substance. That vegetables are possessed of secretory glands, is apparent from the almost infinite variety of their tastes, odours, and colours. These sensible qualities differ even in different parts of the same plant. But the glandular secretion of vegetables is most conspicuous in the flowers and fruit. Many flowers secrete a nectareous fluid, which is more grateful to the palate than the finest honey. The glands of some fruits, as those of the lemon and orange, secrete liquors of very different qualities. The vessels of the rhind contain an acrid essential oil, while those of the parenchyma or pulp secrete an agreeable acid.

This

This similitude in the general structure of animals and plants is strongly corroborated by the analogous parts in both being destined to answer the same purposes.

The oeconomy and functions of vegetables, as well as those of animals, are the results of a vascular texture. Each of these classes of beings have vessels destined to the performance of similar offices. In man and quadrupeds, the fluids are circulated by the pulsation of the heart and arteries. The juices of plants do not circulate; but they are raised from the root to the trunk, branches, leaves, flowers, and fruit, by the sap-vessels. The ascension of the sap has been ascribed to capillary attraction. But, though no motion is perceptible in the sap-vessels similar to the pulsation of arteries; yet, both the propulsion of the sap, which moves with great force, and the secretion of different fluids by different parts of the same plant, imply an action in these vessels. In animals, the gall, the urine, the saliva, are all concocted from the general mass of blood by the action of particular vessels. Fluids of these different qualities exist not in the blood itself: They are created by an incomprehensible operation of the vessels peculiar to their respective glands.

glands. In plants, the sap ascends, and different fluids are secreted from it by glandular vessels. Here the same effects are produced both in the animal and the plant. We must, therefore, attribute them to the same cause, namely, the action of vessels. Besides, the sap, which is the blood of plants, moves with a force often equivalent to the weight of the atmosphere. M. Bonnet remarks *, that he has seen, by means of coloured liquors, the vegetable sap move three inches in an hour; and Dr. Hales, in his Statics, has shown, that the leaves are the principal organs of transpiration. He likewise considers them to be the instruments which raise the sap. But it has since been discovered, that coloured liquors rise equally high in branches deprived of leaves, and that they do not rise at all in dried plants. Hence the sap of vegetables is not taken up in the same manner as a sponge imbibes water, but is forced to ascend by an unknown action of the vessels. The spring of the tracheæ may put in motion the air they contain, and that air may have some influence on the general movement. But, by whatever powers the

* Oeuvres, tom. I. p. 14c.

sap is moved, the existence of the motion is certain; and it is equally certain, that this movement of the sap produces the same effects in the vegetable, that the force of the heart and arteries does in the animal.

The motion of the sap, in vegetables, is not properly a circulation similar to that of the blood in the more perfect animals. It ascends and descends in the same vessels; and these motions are evidently affected by heat and cold. The sap rises copiously in a warm day, and descends during the night, nearly in the same manner as the mercury rises and falls in the thermometer. But, though the analogy here fails with regard to man and the larger animals, yet it holds in the taenia, the polypus, and many other insects, which exhibit not the smallest vestiges of circulation in their juices.

The pith, or medullary substance of plants, has some resemblance to the brain and spinal-marrow of animals. When the texture of the brain or spinal-marrow is destroyed, life is extinguished; and, when the pith of plants is destroyed or dried up by age, they no longer retain the power of vegetating. The leaves of plants are analagous to the lungs of animals. It is by the lungs that the
per-

existence. The lungs of animals likewise derive, from the same sources, a particular matter or principle, without which life could not be long continued.

Another analogy between the structure of plants and animals merits observation. The round bones of animals consist of concentric strata or plates, which can be easily separated; and the wood of plants consists of concentric layers of hardened vessels, which separate when macerated in water. A tree acquires an additional ring every year; and, by counting these rings, a pretty exact estimation of its age may be attained.

The branches of plants have been considered as analogous to the arms or tentacula of animals. But this is one of those strained analogies which should be carefully avoided. The great use of branches is evident. By producing an amazing number of leaves, a large surface is exposed to the air and sun, to answer the important purposes of transpiration and absorption. If there is any thing in plants analogous to the arms or tentacula of animals, it must be confined to such species as twist themselves around poles or trees, as the ivy, the vine, the convolvulus, &c. and to such as support their trunks on
other

other bodies by means of little hooks, as the goose-grass, and many other kinds.

All these analogies, it may be remarked, are confined to large animals and large vegetables; but they hold not in that numerous tribe of plants called *grasses*. Instead of being filled with wood and pith, their stems are perfectly hollow; and, to fortify these plants, Nature has bestowed on them strong joints or knots, which are placed at regular distances in each species. But, though some of the analogies which subsist between the larger animals and vegetables exist not in the smaller plants, this circumstance, instead of infringing, confirms the general plan of Nature. To discover the analogies between tubular plants and animals, we must examine the structure of the minuter tribes of animated beings. The grasses have neither pith nor wood internally; and the polypus, the taenia, and many other insects, have no bones, heart, or intestines, but are simple tubes, perfectly resembling the empty stems of the gramineous plants. Besides, the ligneous, or at least the herbaceous part of these plants, is placed on the outside, similar to the crustaceous and shell animals, whose bones are situated externally. Another analogy must not be omitted.

ted. The succulent vegetables, such as the house-leek, the mushroom tribes, and many sea-plants, consist almost entirely of a pulpy or parenchymatous substance, and may be crushed to a jelly by the slightest pressure. The texture of worms, caterpillars, and of all the soft insects, is extremely similar to that of the succulent vegetables.

II.—GROWTH AND NOURISHMENT.

The second source of analogies between the plant and animal is derived from the modes of their growth and nourishment.

Many ingenious theories have been invented, with a view to explain the mysterious operation by which the growth and nourishment of animals and vegetables are effected. But I shall confine myself, at present, to such remarks as are purely analogical, and may be fully understood without a minute knowledge of the different ways by which growth and nourishment have been supposed to be accomplished.

Animals, like vegetables, gradually expand from an embryo or gelatinous state, and, according to their kinds, arrive sooner or later at perfection. This expansion and augmentation

tation of substance is the idea conveyed by the word *growth*. Without some nutritious matter taken into the body, and assimilated, by the action of vessels, to the substance of the being that receives it, growth cannot take place. Moisture is the chief food of plants. But the food of animals, in general, varies with the species. This fact led some philosophers to conclude, that every plant extracted from the soil a food peculiar to its own nature. It was, however, afterwards discovered, by repeated experiments, that vegetables can grow, and acquire a very considerable degree of bulk and weight, without exhausting a perceptible quantity of the earth in which they are planted. These experiments are a sufficient proof, that moisture constitutes the chief nourishment of plants. They likewise indicate, that vegetables, however diversified in their figure, density, and fibrous arrangement, are more simple in their texture than animals. But, notwithstanding these seeming differences in the nourishment of plants and animals, Nature fails not to observe the same course in both kingdoms. The food of the animal, before it is converted into nourishment, must go through the intricate process of digestion. But, after the
food

food has been converted into chyle, and the chyle into blood, this blood becomes a common fluid, from which all nourishment and all animal fluids are derived. Here the analogy is apparent. Moisture is to the plant precisely what blood is to the animal. Each of them extracts its nourishment from a common fluid ; and, in both, this fluid is changed, by the action of vessels, into the various juices peculiar to the different species.

When growth first commences, the embryos of plants and animals are in similar circumstances. Soon after conception, the foetus is inclosed in its membranes, and is nourished, till mature for birth, by blood which it receives from the uterus and placenta. In the same manner, the embryo of a plant is inclosed in the membranes of the seed ; and its fibrous roots are spread over the lobes or pulpy part. After the seed is sown, and vegetation commences, the embryo is nourished by moisture, which the lobes absorb from the earth, and convey it to the minute tubes of the seminal root. In many plants, these lobes rise above the surface of the ground, in the form of leaves, and continue to nourish and protect the tender plume or stem, till it acquires strength sufficient to support

support the assaults of the air and weather. A plant, in this situation, may be said to have two roots, one, the fibres of which are diffused through the substance of the lobes, or feminal leaves, and another attached to the soil.

The nourishment thus conveyed to vegetables by the feminal leaves, is extremely analogous to that of animals by the milk of the mother. The texture of young animals is so lax and unelastic, that the food suited to maturer years would soon put a period to their existence. But Nature has provided against this inconveniency. She has endowed females with a set of vessels destined for the secretion of a mild liquor, so far concocted and animalized as to be adapted to the tender and flaccid condition of their young. A similar provision of nourishment is afforded to the young vegetable. For some time after the plume and radicle have begun to shoot, their texture is so extremely tender, that they are unable to support each other without some foreign aid. This aid is afforded them by the feminal leaves. These leaves absorb dews, air, and other fine fluids, which are concocted and assimilated in the vessels of the feminal root, and then conveyed, in a kind

kind of vegetable form, to the feeble vessels of the plume. Hence it is apparent, that the nourishment of young animals by milk, and of young vegetables by seminal leaves, is the same institution of Nature, and effected by similar instruments.

Plants, like animals, pass gradually from an embryo, or infant state, to that of puberty. At this period of their existence, they have acquired that firmness of texture, and that evolution of parts, which constitute the perfection of their natures, and enable them to produce beings every way similar to themselves. In both kingdoms, the age of puberty arrives later or more early, according to the difference of species. Some animals live a few months only. Many of the insect tribes are produced, grow to maturity, propagate their kind, and die in the course of a single season. Others, as several flies, beetles, &c. exist two years. Thus animals have a progressive duration of life. The dormouse lives six years, the hare seven or eight, the bear twenty or twenty five, the camel forty or fifty, the rhinoceros seventy or eighty, the elephant two hundred; and some birds and fishes are supposed to exist during three or four centuries. The same progressive duration

ration takes place among vegetables. Some plants are annual, as most of the esculent kinds; others, as the hedge-parsley, the wild carrot, the parsnip, the fox-glove, the scurvy-grass, &c. are biennial; others exist three, five, seven, ten, twenty, thirty, sixty, and a hundred years; and the oak, like the elephant and those birds and fishes which are famed for longevity, continues to adorn the forest for several centuries.

The manner by which the nutritious particles are extracted from food, is very similar in the animal and the plant. In the animal, this operation is performed by the lacteal vessels, which are distributed over the internal surface of the stomach and intestines. In the plant, the same office is performed by the vessels of the root and leaves. Hence animals are organized beings nourished by roots situated within their bodies; and plants are organized bodies which absorb their nourishment by roots placed externally. Besides, in all viviparous animals, the foetus is nourished, not by food taken in at the mouth, but by vessels attached to the placenta. These vessels perform the same office to the foetus, that roots do to vegetables.

Warmth

Warmth and moisture are favourable to the production of large and juicy plants; and the animals that feed upon these succulent and rich vegetables, are likewise larger than those which inhabit cold countries, where the plants are smaller, more rigid, and contain fewer nutritive particles.

Some plants grow in particular climates only. The *rubus arcticus*, a species of bramble, so common in Norway and Canada, hardly endures the climate of Upsal, in Sweden. But the *alsine media*, or chickweed, and several grasses, are diffused over almost the whole globe. In the same manner, some animals, as the camel, the rhinoceros, and the elephant, are produced in warm climates only; while others, as the rein-deer, glutton, and marmot, are confined to the colder regions of the earth; and man, in the animal, like some grasses in the vegetable kingdom, is universal, and inhabits every climate.

Some plants, as well as some animals, are amphibious, as the rush and the frog; others are parasites, and feed on the juices they extract from different species to which they adhere. The mistletoe, for example, feeds upon the oak; most trees afford nourishment to certain

certain mosses and fungous plants; and every animal is fed upon by smaller kinds.

The growth of plants, like that of animals, may be accelerated or retarded by promoting or checking their perspiration, and by excluding them from proper exercise and air. When men, or other animals, are confined to situations which prevent the free access of pure air, their growth is retarded; and their sickly colour indicates a defect of vigour. Plants, when placed in similar circumstances, are always weak, dwarfish, and unnaturally coloured. But exercise is equally necessary to the health and vigour of plants, as it is to those of animals. The exercise of animals is effected by various kinds of spontaneous motion. Plants are likewise exercised by motion; but that motion is not voluntary: It is communicated to them by the action of the air. The agitation which they receive from the winds enables them to extend their roots, prevents them from a growth too rapid, and, of course, strengthens their whole fabric. It is owing to the want of this agitation, that plants brought up in houses, or in other confined situations, shoot out to an unnatural length; that their stems and branches are al-

ways

ways slender and weak; and that they ripen not their fruit like those which are exposed to the open air.

To conclude this branch of the subject, plants and animals are so nearly allied, that their growth and nourishment are not only effected by similar instruments, but some parts of animal bodies evidently partake of a vegetable nature. Thus, the hairs, the nails, the beaks, and the horns, are a species of vegetables, as appears from their comparative total insensibility, as well as from the mode of their growth and reproduction.

III.—DISSEMINATION AND DECAY.

WE shall next take an analogical view of the dissemination and decay of the animal and vegetable.

The power of reproduction is peculiar to the plant and animal. Each of them is capable of producing beings every way similar to the parent. But the modes by which this singular effect is accomplished, are very different in appearance. It is our present purpose to remove this apparent difference, and to show that animals and vegetables multiply their species in a manner extremely analogous.

Animals

Animals have long been divided into viviparous and oviparous. The one class produce their young alive, the other lay eggs, which must be hatched either by the heat of the sun, or by that of the mother. This division, though very comprehensive, is not perfect. Several animals have lately been discovered which are neither viviparous nor oviparous; and there are animals which unite both these modes of multiplication.

The viviparous class comprehends men, quadrupeds, and some fishes, reptiles, and insects. The oviparous includes birds, some reptiles, and most of the insect tribes. But the armed polypus, or *hydra* of Linnaeus, instead of being either viviparous or oviparous, multiplies its species, as formerly remarked, by sending off shoots from the body of the parent.

Another species, called the *bell-polypus*, or *hydra stentorea* of Linnaeus, multiplies by splitting longitudinally. In twenty-four hours, these divisions, which adhere to a common pedicle, resplit, and form four distinct animals. These four, in an equal time, again split; and thus they proceed doubling their numbers daily, till they acquire a figure somewhat resembling a nosegay. The young afterwards

terwards separate from the parent stock, attach themselves to the roots or leaves of aquatic plants, and each individual gives rise to a new colony.

The funnel-shaped polypus multiplies by splitting transversely. Of the individuals, accordingly, which proceed from this division, one has the old head and a new tail, and the other a new head and the old tail. The superior division swims off, and fixes itself to some other substance; but the inferior division remains attached to the former pedicle.

The dart-millepes affords another example of multiplication by spontaneous separation. This insect divides, about two-thirds below the head, into two distinct and perfect animals; and it seems to possess no other mode of continuing the species.

The multiplication of the various animalcules which appear in infusions of animal and vegetable substances, long occupied the attention, and eluded the researches of philosophers. This discovery of the increase of some larger animals by spontaneous division, gave rise to the conjecture, that these microscopic animalcules might multiply their numbers in a similar manner. This conjecture was communicated to M. de Saussure in a letter from

Bonnet,

Bonnet, who received an answer, dated at Genoa, September 28, 1769, to the following purpose.

‘What you propose as a doubt,’ says M. de Sauffure, ‘I have verified by incontestible experiments, namely, that infusion-animalcules multiply by continued divisions and subdivisions. Those roundish or oval animalcules that have no beak or hook on the fore part of their bodies, divide transversely. A kind of stricture or strangulation begins about the middle of the body, which gradually increases, till the two parts adhere by a small thread only. Then both parts make repeated efforts, till the division is completed. For some time after separation, the two animals remain in a seemingly torpid state. They afterwards begin to swim about briskly. Each part is only one half the size of the whole: But they soon acquire the magnitude peculiar to the species, and multiply by similar divisions.’—

‘To obviate every doubt,’ continues our author, ‘I put a single animalcule into a drop of water, which split before my eyes. Next day, I had five, the day after, sixty, and, on the third day, their number was so

VOL. I. E ‘great,

‘ great, that it was impossible to count
‘ them *.

‘ Another species, with a beak or horn on
‘ the fore part of its body, which I obtained
‘ from an infusion of hemp-feed, multiplied
‘ likewise by division, but in a manner still
‘ more singular than the former. This ani-
‘ malcule, when about to divide, attaches it-
‘ self to the bottom of the infusion, contracts
‘ its body, which is naturally oblong, into a
‘ spherical form, so that the beak entirely disap-
‘ pears. It then begins to move briskly round,
‘ sometimes from right to left, and some-
‘ times from left to right, the centre of moti-
‘ on being always fixed. Towards the end, its
‘ motion accelerates, and instead of a uniform
‘ sphere, two cross-like divisions begin to ap-
‘ pear. Soon after, the creature is greatly
‘ agitated, and splits into four animalcules
‘ perfectly similar, though smaller than that
‘ from which they were produced. These
‘ four increase to the usual size, and each, in
‘ its turn, subdivides into other four †, &c.

The beauties of Nature have been justly ce-
lebrated in the uniformity of her productions.

* La Palingénésie Philosophique, par C. Bonnet, tom. 1.
p. 428, 429.

† Idem, p. 430.

This uniformity was early remarked, and gave rise to the ancient division of animals into viviparous and oviparous, which continued to be adopted as an universal maxim till within these hundred years. Before this period, it was believed by philosophers, that all animals were either brought forth alive, or hatched from eggs. Among the ancients, indeed, and even down to the time of the celebrated Redi, this maxim included chiefly the more perfect animals; for, with regard to most of the insect tribes, they imagined that these were produced by putrefaction, and the admixture of particular kinds of matter. But Redi, by a series of unquestionable experiments, exploded the doctrine of the equivocal generation of insects; and then the maxim, without further investigation, was extended to the whole animal kingdom. Redi's experiments and remarks turned the attention of philosophers to the minuter tribes of animals. In the course of a few years, accordingly, several eminent men arose. Reaumur, Bonnet, Trembley, Ellis, Spalanzani, and a multitude of other writers, opened new views with regard to the manners and oeconomy of animated beings. M. Bonnet has furnished incontestible evidence, that several

species of the puceron, or vine-fretter, are both oviparous and viviparous*. In summer, these insects bring forth their young alive; but, in autumn, they deposit eggs upon the bark and branches of trees. Here the intention of Nature is apparent. The puceron is unable to survive the winter colds; and, therefore, though viviparous during the warm months, the species could not be continued without this wise provision. The puceron, it should appear, is naturally disposed to produce live young. The foetus is inclosed in a membrane, which, like that of the larger animals, bursts before exclusion. But, when the cold season commences, the general texture of the animals, as well as of the membranes inclosing the foetus, becomes more firm and tenacious; and this, perhaps, is the physical reason why they are viviparous in summer, and oviparous in autumn. Many other flies are known to be viviparous. Upon farther examination, all these will probably be discovered to be also oviparous†.

The puceron exhibits another phaenomenon still more singular. The maxim, that

* *Traité d'Insectologie*, par C. Bonnet, tom. 1. p. 194, 202.

† See Reaumur, tom. 8. edit. 12mo. p. 153, *et seq.*

multiplication presupposed impregnation by sexual embraces, was formerly thought to be universal. Neither should the reception of this maxim be regarded as a matter of wonder; for it was founded on a very general and strong analogy. But the following facts show, that Nature, though uniform in many steps of her progress, is not invariably limited to the same mode of operation.

On the 20th day of May, M. Bonnet took a young puceron, the moment after dropping from the womb of its mother, and shut it up in a glass vessel, to prevent all possibility of communication with any individual of the species. A sprig of the tree on which the animal was produced, supplied it with nourishment. The creature changed its skin four times, namely, on the 23d, 26th, 29th, and 31st days of the same month. After a minute detail of circumstances, M. Bonnet informs us, that his imprisoned puceron grew with rapidity; that, on the first day of June, it brought forth; and that, from this day to the 21st, it produced no less than 95 young, all full of life and vigour†. He frequently

† Bonnet, *Traité d'Insectologie*, tom. 1. p. 39.; and Reaumur, tom. 12. p. 353.

repeated

repeated this experiment, and it was always followed with the same event.

M. Bonnet, suspecting that a single impregnation might influence both the mother and her immediate offspring, resolved to obviate every difficulty. For this purpose, he confined, in separate glasses, the young of successive births, as they dropped from their mothers. Each of these, however, were equally fertile, though he continued the experiment to the ninth generation from the original parent*.

Facts of this kind, which seem to interrupt the ordinary current of Nature, should inspire philosophers with caution. They should create reverence for such of her operations as are already known; but they should likewise check that rash spirit which too frequently draws unlimited conclusions, before the subject be fully investigated. Of all inductions regarding the history of Nature, the necessity of sexual commerce for multiplying the species appeared to be the most general and the most legitimate. The oeconomy of the puceron, however, demonstrates, that even this law is not indispensable, and that Nature has the power of changing her steps, and of

* Bonnet, *Traité d'Insectologie*, tom. I. p. 74, *et seq.*

accomplishing the same purposes by various means.

Having enumerated the different modes by which animals multiply their species, I shall next show, that the multiplication of vegetables is extremely analogous.

The viviparous, as well as the oviparous animals, are supposed to proceed from eggs, with this difference, that the young of the viviparous are hatched in the uterus previous to their exclusion.

Many striking analogies subsist between the eggs of animals and the seeds of plants. When placed in proper circumstances, they both produce young every way similar to the parents. To accomplish this wonderful effect, the egg requires impregnation and heat. Moisture, warmth, and soil, or some similar matrix, are necessary for the exclusion of the young plant. This analogy has been extended much farther by Linnaeus, and other supporters of the sexual system of plants. They maintain, that impregnation is equally indispensable to the vegetation of the seed, as to the fertility of the egg. But, as this doctrine will be discussed when we come to treat of sexes in general, we shall here dismiss it without farther remark.

Eggs

Eggs are not only analagous to feeds, in their general destination of reproducing individuals, and continuing the species, but there is a great simlarity in the structure and uses of their respective organs.

The internal parts of the egg are covered with a crust or shell, and two membranes. Beside these, the yoke is included in a separate membrane. When the two first membranes are removed, the white appears every way investing the yoke. In the white, or rather on the membrane of the yoke, a small cicatrice is, discernible, in the centre of which is the *punctum saliens*, or embryo of the future animal. After two or three days incubation, this *punctum saliens* becomes red, and shoots out blood-vessels, which are dispersed through the yoke, in the same manner as the vessels of a foetus are distributed over the placenta.

A feed is likewise covered with a shell, or crustaceous membrane. Another membrane invests the whole kernel, or pulpy lobes of the feed. Each lobe, like the yoke of the egg, is involved in a separate membrane. In every feed there is also a small cicatrice, or aperture, through which the young plant issues. Immediately under this cicatrice,

trice, the plume, or future plant, is discernible, resembling the *punctum saliens* of the egg. The branches of the radicle proceed from this plume, and are dispersed through the substance of the lobes, in the same manner as the blood-vessels issue from the *punctum saliens* of the egg, and are distributed over the yoke. It is by the pulp of the lobes that the radicle and plume are nourished, till the one shoots down into the soil, and the other mounts above the surface. In seeds, there is nothing analogous to the white of an egg. Such a provision would have been superfluous; for the earth, in which the seeds are to germinate, must always be moist, otherwise the young plant could not receive nourishment, after issuing from the seed. Besides the eggs of fishes have no white, because they are perpetually moistened with water.

The analogies arising from the multiplication of animals and plants, by means of eggs and seeds, are the most common, and the most obvious. Eggs and seeds are evidently organs formed on the same plan, and destined by Nature to answer the same general intention: But the multiplication of plants, as well as that of animals, is not confined solely to one mode.

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The young of viviparous animals, though they probably originate from small eggs, are not brought forth till they have acquired a certain age and firmness of texture. It may be thought, that there is no multiplication of plants which has any resemblance to that of viviparous animals. We should reflect, however, that plants can multiply by buds. Now, a bud has no analogy, either in texture or appearance, to a seed. Buds arise from the stems or branches of vegetables. One object in their formation is to produce leaves and branches, as well as to extend the length of the trunk or stem. But they are likewise endowed with the faculty of reproducing new individuals. In this respect, trees and shrubs may be considered as viviparous plants; because they produce out of their own bodies an organ, which, though differing in every view from a seed, is brought forth alive, and, when properly cherished, is converted into a being perfectly similar to the parent, and capable of continuing its species. The embryo of a bud commences its existence under the bark. Here it remains, for some time, inclosed in membranous coverings, and attached to the bark by minute fibres, which convey to it a nourishment suited to its condition.

dition. . When arrived at a certain size and consistence, it pierces the bark, and shoots out into the open air. If allowed to remain on the parent, it soon bursts through its membranes, and, in time, gives rise to a new branch: But, when detached from the parent, and placed in proper circumstances, it becomes a new individual of the same species.

Bulbous rooted plants furnish a still stronger analogy between the increase of viviparous animals and that of vegetables. In the end of autumn, if the coats of any bulbous root be carefully dissected, the entire plant in miniature will appear in the centre of the root. In spring, this small plant, like a foetus inclosed in the uterus, pierces the coats of which the root consists, and gradually grows till it flowers, ripens its seeds, and dies at the approach of winter, when a new plant is again formed in the old root. Here we have an example of the multiplication of plants similar to that of the puceron; but the order of time is reversed. The puceron is viviparous in summer, and oviparous in autumn; but bulbous-rooted plants may be considered as oviparous in summer, and viviparous in autumn.

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The same analogy is to be traced in those roots which have what are called *eyes*, like the potatoe. These eyes are all plants in miniature, which live in that state during the winter, and, when committed to the soil, come to maturity in summer.

There are still other modes of multiplying common to the animal and vegetable. Many plants are multiplied by suckers, slips, and cuttings.

The animal kingdom furnishes examples of all these modes of multiplication. The suckers of plants have an exact analogy to the shoots of a polypus. When separated from the parent, the sucker becomes a perfect plant, and the shoot of the polypus a perfect animal. Plants are capable of multiplication by slips and cuttings: And the portions of a polypus, however small, or when cut in any direction, reproduce, and become perfect animals of the same species.

But some species of the polypus, the darters, millepes, and several animalcules which appear in infusions of animal and vegetable substances, multiply by splitting, or spontaneous separation. Here the analogy between the animal and vegetable might be supposed to fail. The water-lentil, however, a small plant,

plant, which covers the surface of stagnating pools, multiplies its species by detaching thin films from the under side of the leaf. These films or tender leaves produce roots, and vegetate into a regular plant.

We must now dismiss the subject till another analogy be unfolded. All animals have seasons peculiar to their respective kinds. Some of the larger animals produce in the spring, others in summer, others in autumn, and others in winter. With regard to the insect tribes, their seasons are still more various. Every month, every week of the year, gives birth to different species. The seasons of plants are diversified in a similar manner. The growth of different vegetables is distributed over the whole year. Particular tribes spring up at the same uniform periods. In this beautiful diversity of arrangement, the intentions of Nature are evident. If all plants were to rush forward at the same time, they would infallibly choke each other. The surface of the earth could not afford them room. Nature has therefore wisely ordained, that the earth should always be covered with plants: But she has also ordained, that particular tribes should die at stated periods, to make way for the existence of others. The same inconvenience would happen, if the
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production of all animals, and particularly that vast number of species, and that immense profusion of individuals, to which the insect tribes give birth, were to take place at one period. The air would be so crowded with noxious creatures, that neither man nor the larger animals could possibly exist. Besides, the species which feed upon particular plants, if they were produced at a time when these plants did not flourish, would infallibly perish for want of food. In Lapland, where the duration of heat is extremely short, the whole insects which inhabit that dreary and barren region are produced in a few weeks. Though the number of species, compared with those of the more prolific climates, be very limited, the inconvenience is severely felt. But every natural evil is accompanied with some advantage. The reindeer, upon which the existence of the Laplanders chiefly depends, are tormented by the swarms of flies. To avoid their numberless enemies, these animals leave the vallies, and ascend the mountains, where the cold is too great for the flies to follow. In these lofty regions, the rein-deer feed during the hot season, and return to the vallies after the cold has destroyed the myriads of insects. This forced migration has two good effects: It both preserves the

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the health of the rein-deer, and the vegetables in the vallies, which otherwise would have been prematurely exhausted.

The operation of engrafting was long thought to be peculiar to the vegetable kingdom. But M. Trembley found, that several species of the fresh-water polypus could successfully undergo this wonderful process. Since his time, it has been discovered, that the *actinia*, or sea-nettle, is likewise capable of being engrafted to an individual of the same or of a different species. In all these instances, the portions of the divided animals grow together, and become distinct individuals.

Having traced the general analogies between the structure and oeconomy of the animal and vegetable, from the rudiments of their existence till they have acquired full maturity, and performed the necessary office of multiplying their species, we proceed to the last and only melancholy branch of this subject, the unavoidable decay and death of every successive individual in both kingdoms.

It is an invariable law of Nature, that all organized bodies should have a constant tendency to dissolution. But the periods of their existence vary according to the species. Previous to actual resolution, plants as well as animals

animals are subject to a number of analogous affections and diseases. When over-heated, plants shew evident marks of languor and fatigue: Their leaves become flaccid, their stems and branches bend toward the earth, their juices evaporate, and their whole texture assumes the appearances of weakness and decay. The application of too great a degree of cold makes the flowers, the leaves, the bark, and even the woody fibres, shrivel and contract in their dimensions. When deprived of proper light and air, their colours fade, and they soon acquire a lurid and sickly aspect. They are likewise subject to be starved for want of nourishment. The growth of plants, as well as that of animals, is checked by scanty supplies of food. When the soil or situation is unkindly, vegetables are always weak and dwarfish, and their prolific powers are diminished. They may also be poisoned by the absorption of fluids hostile to their constitution. Beside these general affections, common to the plant and animal, vegetables are injured, and often killed, by particular diseases.

Some diseases attack the leaves only, and produce spots of various colours, rugosities, pustules, galls, &c. Others are peculiar to the flowers and fruit, and often occasion barrenness

renness for a season; and sometimes this fertility continues during the existence of the plant. Others assault the viscera, or internal organs, and give rise to obstructions, tumors, and a gradual resolution and corruption of the whole fabric. Many of the diseases of plants are produced by the insect tribes. Their wounds and depredations are not confined to particular parts, but extend from the root to the stem, branches, leaves, flowers, and fruit. Insects not only injure the substance of plants, but, by feeding on their juices, deprive them of a part of their nourishment, and occasion various diseases or changes in their organization. Other diseases of plants derive their origin from change of climate, from miasmata or noxious vapours in the atmosphere, and from improper culture. When wounded by external injuries, vegetables discharge their blood in copious streams. If the wound be not mortal, the fibres on all sides gradually shoot out, and close the fracture by a callous substance.

From this general enumeration, it is obvious, that the diseases of plants are not only similar to those of animals, but proceed from the same causes. In both kingdoms, some diseases are only partial or superficial, and

are cured either by Nature, or by the assistance of art. Others are mortal, and succeeded by a total putrefaction or decomposition of the individual.

But, though plants should escape the numberless diseases which daily threaten them, they have no defence against the slower approaches of old age, and its unavoidable consequence, death. In progress of time, the vessels gradually harden and lose their tone. The juices no longer move with equal celerity as in youth. They are not absorbed with the same precision. They at last stagnate and corrupt. This corruption is soon communicated to the vessels in which the juices are contained, and produces a total cessation of all the vital functions.

The life of animals is diversified by a number of successive changes. Infancy, youth, manhood, old age, are characterised by imbecillity, beauty, fertility, dotage. All these vicissitudes are conspicuous in the vegetable world. Weak and tender in infancy, beautiful and vigorous in youth, robust and fruitful in manhood, and, when old age approaches, the head droops, the springs of life dry up, and the tottering vegetable, like the animal,

mal, returns to that dust from which it sprung.

Upon the whole, by taking a retrospective view of the extreme difficulty of ascertaining the boundaries which distinguish the animal from the vegetable, and of the similarities in their structure and organs, in their growth and nourishment, in their diffemination and decay, it is apparent, that both these kingdoms constitute the same order of beings, and that Nature, in the formation of them, has operated upon one great and common model.

CHAPTER II.

Of the organs and general structure of Animals—A short view of the external and internal parts of the human body—This structure compared with those of Quadrupeds, Birds, Fishes, and Insects—How far peculiarities of structure are connected with peculiarities of manners and dispositions.

IN Treating of this subject, it is not intended to dive into the depths of anatomical research. On the contrary, I shall exhibit short views only of the general structure and organization of the various classes of animated beings, from man, who is the most perfect animal of which we have any knowledge, down to the insect tribes. Considering man, therefore, as the standard of animal perfection, we shall institute frequent comparisons, and mark peculiar distinctions between him and the brute creation, both with regard to form, manners, and sagacity. By following this plan, I hope I shall be enabled to render a subject which, at first sight, may have a forbidding aspect, both interesting and agreeable.

S T R U C.

STRUCTURE OF MAN.

The bones may be regarded as the basis upon which the human body is constructed. The spine, or back-bone, consists of a number of vertebrae, or small bones, connected together by cartilages, articulations, and ligaments. In the centre of each vertebra there is a foramen, or hole, for the lodgement and continuation of the spinal marrow, which extends from the brain to the rump. From these vertebrae the arched bones called ribs proceed; and seven of them join the breast-bone on each side, where they terminate in cartilages, and form the cavity of the thorax, or chest. This cavity contains the heart and lungs; and the oesophagus, or gullet, passes through it to reach the stomach. The five lower ribs, with a number of muscles, form another cavity termed the *abdomen*, or belly, in which are contained the stomach, the bowels, the *omentum*, or cawl, the liver, the gall-bladder, the spleen, the pancreas, and the kidneys. The chest and abdomen are separated from each other by the diaphragm, or midriff. The lower part of this last cavity contains the bladder of urine, and the rectum, or termination of the intestines. Beside these, in females, the pelvis includes the uterus and its appendages. This part of the cavity is
formed

formed by the os sacrum, or termination of the back-bone, and the two ossa innominata.

The bones of the cranium and face are very numerous. They are connected together by means of sutures, articulations, and membranes. The bones of the cranium include the brain, and its two membranous coverings, called the *pia* and *dura mater*, and the medulla oblongata, of which last the spinal marrow is a prolongation. The bones of the upper and under jaw form another cavity for the reception of the tongue and organs of speech.

The only remaining bones are those of the upper and lower extremities. The shoulder and collar bones articulate with the top of the arm and the breast-bone. The arm-bone, or *os humeri*, is joined to the two bones of the fore-arm, called *ulna* and *radius*, and these last to the bones of the *carpus*, or wrist, by means of articulations and firm membranes. To the bones of the wrist, those of the metacarpus and fingers are attached in a similar manner.

With regard to the lower extremities, the thigh-bone articulates above with the hip-bone, and below with the leg-bone and the rotula, or knee-pan. The leg, like the fore-arm, is composed of two bones, the tibia and fibula,

fibula, which articulate with each other, and with the tarsal, or heel-bones of the foot; and to these last the metatarsal bones, and those of the toes, are joined.

From this outline, some idea may be formed of the human skeleton. The other parts of which our bodies are composed shall be mentioned in the same cursory manner.

The muscular part of the human fabric consists of numerous bundles of fleshy fibres. Each bundle, or distinct muscle, is inclosed in a cellular membrane, by which means they may be raised, or separated from one another by the hand of the anatomist. They are inserted, by strong tendinous extremities, into the different bones of which the skeleton is composed, and, by their contraction and distention, give rise to all the movements of the body. The muscles, therefore, may be considered as so many cords attached to the bones; and Nature has fixed them according to the most perfect principles of mechanism, so as to produce the fittest motions in the bones or parts for the movement of which they are intended.

The heart is a hollow muscular organ of a conical shape, and consists of four distinct cavities. The two largest are called *ventricles*, and the two smallest *auricles*. The
heart

heart is inclosed in the *pericardium*, a membranous bag, which likewise contains a quantity of water, or lymph. This water lubricates the heart, and facilitates all its motions. The heart is the general reservoir of the blood. By the contractions and dilatations of this muscle, the blood is alternately thrown out of, and received into, its several cavities. When the heart contracts, the blood is propelled from the right ventricle into the lungs through the pulmonary arteries, which, like all the other arteries, are furnished with valves that play easily forward, but admit not the blood to regurgitate toward the heart. The blood, after circulating thro' the lungs, returns into the left ventricle of the heart by the pulmonary vein. At the same instant, the left ventricle drives the blood into the aorta, a large artery which sends off branches to supply the head and arms. Another large branch of the aorta descends along the inside of the back-bone, and detaches numerous ramifications to nourish the viscera and inferior extremities. After serving the most remote extremities of the body, the arteries are converted into veins, which, in their return toward the heart, gradually unite into larger branches, till the whole terminate in one great trunk called the *vena cava*, which discharges

discharges itself into the right ventricle of the heart, and completes the circulation.

Beside the heart, the thorax or chest contains the lungs, or organs of respiration. They are divided into five lobes, three of which lie on the right, and two on the left side of the thorax. The substance of the lungs is chiefly composed of infinite ramifications of the trachea or windpipe, which, after gradually becoming more and more minute, terminate in little cells or vesicles, which have a free communication with one another. At each inspiration, these pipes and cells are filled with air, which is again discharged by respiration. In this manner, a circulation of air, which is necessary to the existence of men and other animals, is constantly kept up as long as life remains.

The instruments and process of digestion fall next to be considered. The stomach is a membranous and muscular bag furnished with two orifices: By the one it has a communication with the *oesophagus*, or gullet, and by the other with the bowels, which begin at the stomach and terminate at the anus. In the stomach and intestines there are immense numbers of minute vessels called *lacteals*, the mouths of which are constantly open for the reception of the nutriti-

ous particles. After being moistened and lubricated by the saliva, the food is received into the stomach, where it is still farther diluted by the gastric juice, which has the power of dissolving every kind of animal and vegetable substance. When the food has remained some time in the stomach, it is reduced to a grayish pulp, mixed with some chylous or milky particles. The thinner and more perfectly digested parts of the food pass through the *pylorus*, or lower aperture of the stomach, into the intestines, where they are still farther attenuated and digested by the bile and pancreatic juices. While the food is in this fluid state, it receives the denomination of *chyle*, and is continually absorbed by the mouths of the lacteal veins. These vessels arise, like net-work, from the inner surface of the intestines, pass obliquely thro' their coats, and, running along the mesentery, unite, as they advance, into larger branches, and at last terminate in the thoracic duct, or general receptacle of the chyle. Beside the lacteals, there is another system of vessels called *lymphatic*, or absorbent veins: They are minute pellucid tubes, and generally lie close to the large blood-vessels. The lymphatics from all the lower parts of the body gradually unite as they approach the
thoracic

thoracic duct, into which they pour a colourless fluid by three or four large trunks; and the lymphatics from all the superior parts of the body likewise discharge their lymph into the same duct as it runs upward to terminate in the left subclavian vein. By this curious and beautiful machinery, the chyle and lymph, which consist of the nutritious matters extracted from the food, enter the circulating system, are converted into blood, and afford that constant supply of nourishment which the perpetual waste of our bodies demands.

We shall next give a sketch of those important organs by which we are enabled to multiply and continue the species. The circulation of the blood, and the mode by which the quantity of it is continually kept up by fresh supplies of chyle, are effects which, in some measure, correspond with our ideas of the machinery employed. The organs of generation exhibit a still more complex specimen of exquisite mechanism. But the machinery employed, without the aid of experience, could never suggest the most distant idea of the effect to be produced.

In the male, the organs of generation consist of the testes, the seminal vessels, and the penis. The testes are two glandular bodies which

which possess the power of converting the blood into semen. They are originally formed and lodged in the abdomen; and it is not till after birth that they commonly pass into the groin, and from thence fall into the scrotum, which is a muscular bag prepared for their reception and defence. The testes of the hedgehog and of some other quadrupeds remain in the abdomen during life. Instances of the same kind sometimes happen in the human species. Each testicle is composed of the spermatic artery and vein. The blood passes very slowly through the spermatic artery, and produces an infinite number of convolutions in the substance of the testicle, where it deposits the semen, which is taken up by the seminiferous tubes. These tubes at length unite, and, by an immense number of convolutions, form a kind of appendix to the testicle, commonly known by the term *epididymis*. The tubes of the epididymis, after terminating in an excretory duct called *vas deferens*, ascend toward the abdominal rings, and deposit the semen in the seminal vesicles, which are two soft convoluted bodies situated between the rectum and bladder, and unite at their lower extremity: From these reservoirs the semen is occasionally discharged through the short canals which open into the urethra.

urethra. The penis is a cavernous and spongy substance perforated longitudinally by a canal called the *urethra*, which, by communicating with the bladder and feminal vessels, answers the double purpose of discharging both the urine and semen.

With regard to the female organs, the uterus and its appendages merit a principal attention. The uterus is a hollow muscular body situated between the rectum and bladder, and, when not in an impregnated state, resembles a pear, with the thickest end toward the abdomen. The entrance into the cavity of the uterus forms a small protuberance, which has been compared to the mouth of a tench, and from this circumstance it has received the name of *os tincae*. The uterus is connected to the sides of the pelvis by two broad ligaments, which support it in the vagina in a pendulous situation. From each side of the bottom of the uterus the two Fallopian tubes arise, pass through the substance of the uterus, and extend along the broad ligaments till they reach the edge of the pelvis; from whence they are reflected backward, and turning over behind the ligaments, their extremities hang loose in the pelvis. These extremities, because they have a ragged appearance, are called *fimbriae*, or
morfus

morsus diaboli: Each Fallopian tube is about three inches long. Their cavities are at first very small, but become gradually larger, like a trumpet, as they approach the fimbriae. Near the fimbriae of each tube, about an inch from the uterus, are situated the ovaria, or two oval bodies, about half the size of the male testicle. They are covered with a production of the peritoneum, and hang loose in the pelvis. In their substance there are several minute vesicles filled with lymph. The number of these vesicles seldom exceeds twelve in each ovarium. In mature females, these vesicles become exceedingly turgid; and a yellow coagulum gradually forms in one of them, which increases till its coat disappears. It then changes into a hemispherical body called *corpus luteum*, which is described as being hollow and containing within its cavity very minute eggs, each of which, it is supposed, may be impregnated, and produce a foetus. After impregnation, one of these eggs, as we are informed by anatomists, is absorbed by and passes through the Fallopian tube into the uterus, where it is nourished till mature for birth.

We shall conclude this subject with a concise account of the instruments of sensation.

The organs hitherto described convey nothing

thing more than the idea of an automaton, or self-moving machine. But sensation, or the perception of pleasure and pain, is effected by organs of a peculiar kind. These organs are all comprehended under the general appellations of the *brain* and *nerves*.

Beside the bones of the cranium, the brain is invested with two membranes, called *dura* and *pia mater*, because they were supposed by the Arabians to be the source of all the other membranes of the body. Under the denomination of *brain* are comprehended three distinct parts, the *cerebrum*, the *cerebellum*, and *medulla oblongata*. The *cerebrum* is a soft medullary mass, situated in the anterior part of the skull, and divided, by a portion of the *dura mater*, into two hemispheres. It consists of two substances, the cortical, which is greyish, and the medullary, which is softer, and of a very white colour. The *cerebellum* is divided into two lobes, and its substance is firmer and more compact than that of the *cerebrum*. It is likewise composed of the cortical and medullary substances. The reunion of the medullary substances of the *cerebrum* and *cerebellum*, at the basis of the skull, forms the *medulla oblongata*, of which the spinal marrow is a continuation. The
brain

brain of the human species is proportionally much larger than that of quadrupeds.

The brain and spinal marrow are supposed to be the origin of all the nerves or instruments of sensation. The nerves are, in general, cineritious, shining, inelastic cords. But they differ from each other in size, colour, and consistence. From numberless experiments and observations, it is unquestionable, that the nerves are the instruments both of sensation and of animal motion. But, how these effects are produced by the nervous influence is a discovery still to be made. The inquiry, however, has given rise to several ingenious conjectures and hypotheses. Some physiologists have maintained, that the nerves are solid cords, which may be divided into an infinite number of minute filaments; and that, by the vibrations of these cords, the various impressions and modifications of feeling are conveyed to the brain. Others, with more plausibility, have supposed, that the nerves are assemblages of small tubes; that a subtile fluid, sometimes called *animal spirits*, is secreted in the brain and spinal marrow; and that by the influence or motions of this fluid all the sensations of animals are transmitted to the sensorium, or general repository

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ry of ideas. But it is needless to dwell upon a subject covered with darkness, and which all the efforts of human powers will probably never bring to light.

Anatomists have described forty pair of nerves. Ten of them proceed from the medulla oblongata of the brain, and thirty from the spinal marrow. These nerves, by sending off innumerable ramifications, are distributed, like a net-work, over every part of the body, till they terminate, in the form of minute papillae, upon the skin. That the nerves are the immediate instruments of sensation, as well as of muscular motion, has been proved by a thousand uncontrovertible experiments. When the trunk of the sciatic nerve is cut, the thigh and leg on that side instantly lose all motion, and all sense of pain, below the incision, and neither time nor art can ever restore the power of feeling or of moving. But the parts between the incision and the spinal marrow, which is a continuation of the brain, retain their usual degrees both of motion and of sensation. From this experiment, it is evident, that the nerves are the organs by which sensation and motion are effected, and that, for these important purposes, an uninterrupted connection between

any particular nerve and the brain, or spinal marrow, is indispensable.

This sketch of the human fabric requires an apology to anatomical readers, who must be sensible of its many imperfections. . To persons who have not studied that curious and useful science, I imagined a general view of the structure of man, if properly composed, might enable them to acquire more distinct ideas of the many seeming deviations from the common plan observed by Nature in the formation of the inferior and more imperfect animals.

OF THE STRUCTURE OF QUADRUPEDS.

Having delineated the structure and organs of the human species, it is worthy of remark, that the intellect, or sagacity, of inferior animals augments or diminishes in proportion as the formation of their bodies approaches to, or recedes from, that of man. Quadrupeds, accordingly, are more intelligent than birds; the sagacity of birds exceeds that of fishes; and the dexterity and cunning of fishes are superior to those of most of the insect tribes. The same gradation of mental powers is exhibited in different species of the same classes of animals. The form of the
orang

orang outang makes the nearest approach to the human; and the arts he employs for his defence, the actions he performs, and the sagacity he discovers, are so astonishing, that some philosophers have considered him as a real human being in the most debased stage of society. Next to the orang outang, the organs of the different species of apes and monkeys have the greatest resemblance to those of man; and their powers of imitation, their address in procuring their food, and in managing their young, their ingenuity, and their sagacious manners, have contributed to the amusement, and excited the admiration, of mankind in all ages and nations. The same relation between form and intellect may be traced to the dog, the cat, the sow, the horse, the sheep, and the other species of quadrupeds.

With regard to the general structure and figure of quadrupeds, a great variety is exhibited in the different kinds. But, when examined in detail, it is apparent, that they, as well as man, are all formed upon one primitive and general design. Beside the organs of sensation, of circulation, of digestion, and of generation, without which most animals could neither subsist nor multiply, there is,

even among those parts that chiefly contribute to variety in external form, such a wonderful resemblance as necessarily conveys the idea of an original plan upon which the whole has been executed. For example, when the parts constituting a horse are compared with the human frame, instead of being struck with their difference, we are astonished at their singular and almost perfect resemblance. Take the skeleton of a man, says Buffon, incline the bones of the pelvis; shorten those of the thighs, legs, and arms; join the phalanges of the fingers and toes; lengthen the jaws by shortening the frontal bones; and, lastly, extend the spine of the back. This skeleton would no longer represent that of a man: It would be the skeleton of a horse. For, by lengthening the back-bone and the jaws, the number of the vertebrae, ribs, and teeth, would be increased; and it is only by the number of these bones, and by the prolongation, contraction, and junction of others, that the skeleton of a horse differs from that of a man. The ribs, which are essential to the figure of animals, are found equally in man, in quadrupeds, in birds, in fishes, and even in the turtle. The foot of the horse, so apparently different from the hand of a man,

is composed of similar bones; and, at the extremity of each finger, we have the same small bone, resembling the shoe of a horse, which bounds the foot of that animal. Raise the skeletons of quadrupeds, from the ape-kind to the mouse, upon their hind-legs, and compare them with the skeleton of a man, the mind will be instantly struck with the uniformity of structure and design observed in the formation of the whole group. This uniformity is so constant, and the gradations from one species to another are so imperceptible, that to discover the marks of their discrimination requires the most minute attention. Even the bones of the tail will make but a slight impression on the observer. The tail is only a prolongation of the *os coccygis*, or rump-bone, which is short in man. The orang outang, and true apes, have no tail; and, in the baboons, and several other quadrupeds, the tail is exceedingly short. Thus, in the creation of animals, the Supreme Being seems to have employed only one great idea, and, at the same time, to have diversified it in every possible manner, that men might have an opportunity of admiring equally the magnificence of the execution and the simplicity of the design.

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In quadrupeds, as well as in man, the bones are connected by articulations and membranes; and the different movements of these bones are performed by the operation of muscles. The number, disposition, and form of the muscles, with a few exceptions arising from the figure and destination of parts peculiar to particular animals, are nearly the same in men and in quadrupeds. The circulation of their blood, the secretion of their fluids, and the process of digestion, are carried on by organs perfectly similar to those of the human body. In the external covering, a small difference takes place. Quadrupeds are furnished with a thick covering of hair, or wool, to defend them from the injuries of the weather. Being destitute of art sufficient to make garments, Nature has supplied that defect, by giving them a coat of hair, which varies in thickness according to the season of the year and the difference of climate. In Russia, Lapland, Kamtschatka, and all the northern regions, the furs of animals are very thick and warm. But, in Turkey, Africa, and the southern parts of Asia and America, most quadrupeds are thinly clad, and some of them, as the Turkish dog, are totally destitute of hair.

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The skin of quadrupeds is disposed nearly in the same manner as the human, only it is more elastic. Immediately under the skin, there is a thin muscular substance, called *panniculus carnosus*, which is common to all quadrupeds, except the hog and armadillo kinds. This substance, which is peculiar to quadrupeds, chiefly covers the trunk, and, by suddenly shaking and shrivelling the skin, enables these animals to drive off insects, or other offensive bodies.

The substance of the nerves, or organs of sensation, is the same in the quadruped and in man. They originate from the brain and spinal marrow, and are distributed over all the internal and external parts of the body, in the same manner as in the human frame.

Thus it appears, that, in general structure and organization, the brute creation is nearly allied to the human species. Some differences, however, merit attention; because a slight variation in structure, especially of the internal organs, is often accompanied with great diversities in dispositions, food, and manners.

Some animals feed upon flesh, others upon vegetables, and others upon a mixture of both. The dispositions of some species are fierce; and their manners convey to us the
ideas

ideas of cruelty and of barbarism : The dispositions and manners of other species are soft and placid, and excite in us ideas of mildness, complacency, and innocence. The ferocity of the tyger and hyaena forms a perfect contrast to the gentleness and inoffensive behaviour of the sheep and the ox. This opposition of manners has given rise to the distinction of animals into rapacious and mild, carnivorous and herbivorous. In the structure of these animals, whose characters are so opposite, some differences have been discovered, which indicate the intentions of Nature in forming them, and fully justify the seeming cruelty of their conduct.

In all the carnivorous tribes, the stomach is proportionally smaller, and the intestines shorter, than in those animals which feed upon vegetables. As animals of the former kind live solely on flesh, the shortness and narrowness of their intestines are accommodated to the nature of their food. Animal food is more easily reduced to chyle, and becomes sooner putrid, than vegetable. Of course, if its juices were allowed to remain long in the intestines, instead of nourishing the body, they would produce the most fatal distempers. Beside this accommodation of
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the intestines to the nature of their food, carnivorous animals are furnished with the necessary instruments for seizing and devouring their prey. Their heads are roundish, their jaws strong, and their tusks very long and sharp. Some of them, as the lion, the tyger, and the whole cat-kind, are provided with long retractile claws. Thus both the internal and external structure of this class of animals indicate their destination and manners. The rapid digestion of their food is a consequence of the strength and shortness of their intestines; and the intolerable cravings of their appetite necessarily create a fierceness and rapacity of disposition. Nothing less than blood can satiate them. Their cruelty, and the devastation they make among the weaker and more timid tribes, are effects resulting solely from the structure and organs with which Nature has thought proper to endow them. Hence, if there be any thing reprehensible in the manners and dispositions of carnivorous animals, Nature alone is to blame; for all their actions are determined by the irresistible impulses of their organization. But, even in this seemingly cruel arrangement, Nature must not be rashly accused. When we come to treat of the hostilities
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of animals, I hope to be able to show, that Nature, in the formation of rapacious creatures, has acted with her usual wisdom, and that beings of this kind have their uses in the general system and oeconomy of the universe.

As to the herbivorous tribes, or those animals which feed upon grain and herbage, a slight variation of organs produces the greatest effects upon their disposition and manners. The intestines of this tribe are very long, capacious, and convoluted. Vegetable food, especially herbage, contains a smaller quantity of nutritive matter than the flesh of animals; neither is it so easily reduced to chyle. A larger quantity, therefore, as well as a longer detention in the stomach and intestines, is necessary for the nourishment of these creatures. Several quadrupeds comprehended under this order ruminate or chew the cud. These are furnished with no less than four stomachs. The food, after mastication, is thrown into the first stomach, where it remains some time; after which, the animal forces it up again into the mouth, and gives it a second chewing. It is then sent directly into the second stomach, and gradually passes into the third and fourth; and, lastly, it is transmitted through the convolutions

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of the intestines, and the dregs, or faeces, are thrown out of the body. By this machinery, herbivorous animals are enabled to devour large quantities of vegetable aliment, to retain it long in their bowels, and consequently to extract from it nutritive matter sufficient for their growth, support and multiplication. Here the quantity compensates the quality of the nutriment.

It is true, that the horse, the ass, the hare, and some other animals which live upon herbage and grain, have only one stomach. But, though the horse and ass have one stomach only, their intestines are furnished with sacs or pouches so large, that they may be compared to the paunch of ruminating animals; and hares, rabbits, the Guiney-pig, &c. have blind guts so long and capacious, that they are equivalent to a second stomach. The hedgehog, the wild boar, the squirrel, &c. whose stomach and intestines are of a mean capacity, eat little herbage, but live chiefly upon seeds, fruits, and roots, which contain, in small bounds, a greater quantity of nutritive matter than the leaves or stems of plants.

The external form of herbivorous animals, like that of the rapacious, is accommodated to their dispositions and the oeconomy they are

are obliged to observe. That they might be enabled to reach the surface of the earth with ease, the legs of the larger kinds are proportionally short; their head and neck long; and the muscles and tendons of the neck are endowed with prodigious strength. Without these peculiarities of structure, they could not support the prone posture of the head in the tedious operation of browsing large quantities of herbage. The arrangement and form of their teeth likewise indicate the destination of the ruminating tribes. They have no cutting teeth in the upper jaw; and they are totally deprived of tusks, or canine teeth. This last circumstance, joined to their want of claws, shews that they are not intended to prey upon other animals. Horns are the only weapons of defence with which they are provided. From the nature of their food, therefore, and the internal and external configuration of their bodies, it is evident, that animals of this description must be humble in their deportment and mild in their disposition. This order of animals, accordingly, have uniformly been celebrated for gentleness of manners, submission, and timidity. Man has availed himself of those dispositions, by reducing almost the whole of this tribe to a domestic state

state. But, in all this graciousness of aspect and tractability of temper, the animals themselves have no merit. Their motions and actions are necessary results of the organs which Nature has bestowed on them. It is obvious, therefore, that the diversity of tastes and dispositions exhibited by different animals, arises not solely from any superior agreeableness of particular kinds of food to their palates, or to a particular bias of their minds to benevolence and peace, but from a physical cause depending on the structure of their bodies.

From what has been advanced, it follows, that man, whose stomach and intestines are proportionally of no great capacity, could not live upon herbage alone. It is an incontestible fact, however, that he can live tolerably well upon bread, herbs, and the fruits, roots and seeds of plants; for we know whole nations, as well as particular orders of men, who are prohibited by their religion from eating any animal substance. But these examples are not sufficient to convince us, that the health, vigour, and multiplication of mankind would be improved by feeding solely upon pot-herbs and bread. Besides, his stomach and intestines are of a mean capacity between those of the carnivorous and herbivorous

bivorous animals. From this circumstance alone we are warranted to conclude, that Nature intended him to feed partly on animal and partly on vegetable substances: And daily experience teaches us, that men fed in this manner are larger, stronger, and more prolific, than those who are confined to a vegetable diet. If man had no other sources of superiority over the other animals than those which originate from the structure of his body, his dispositions ought to be a medium between those of the carnivorous and herbivorous tribes. When considered merely as an animal, this appears to be really the case. Vulgar and uninformed men, when pampered with a variety of animal food, are much more choleric, fierce, and cruel in their tempers than those who live chiefly on vegetables. Animal food heats the blood, and makes it circulate with rapidity. In this situation, every object capable of exciting appetite or passion operates with redoubled force. The weak mind yields to the impulse, and gives vent to every species of outrage which can debase human nature.

In the formation of his body, man has some advantages over particular animals. But these advantages are inconsiderable, and
none

none of them, perhaps, are peculiar to the species. The structure of all animals is nicely adjusted to their destination, and the station they occupy in the general scale of Being. The body of man is erect, and his attitude is said to be that of command. His majestic deportment, and the firmness of his movements, announce the superiority of his rank. His arms are not mere pillars for the support of his body. His hands tread not the earth; neither do they lose, by friction and pressure, that exquisite delicacy of feeling for which Nature had originally intended them. His arms and hands, on the contrary, are formed for purposes of a more noble kind. They are destined for executing the commands of his will, for laying hold of bodies, for removing obstacles, for defending him from injuries, and for seizing and retaining objects of pleasure. The features of this picture are exact delineations; but they are not the exclusive privilege of man. The orang outang walks erect, and he derives equal advantages from his hands and arms as the human species. Some apes have likewise the power of walking erect, with the additional faculty of employing their hands and arms as legs. They can walk, run, or leap, by the instrumentality

ty either of two or of four extremities, as their situation or necessities may require. It is not, therefore, the fabric of man's body that entitles him to claim a superiority over the other animals. The formation of their bodies is adjusted with equal symmetry and perfection to the rank they hold in the general system of animation. Many of them excel us in magnitude, strength, swiftness, and dexterity in particular movements. Their senses are often more acute; they seize their prey, or procure herbage, fruits, and seeds of trees, with more facility than man, when limited to the powers of his animal nature. Hence the great source of man's superiority over the brute creation must be derived from his mental faculties alone. Brutes enjoy the same instincts, the same appetites, and the same propensities, as appear in the constitution of the human mind. But the instincts of brutes, though they are exerted with great certainty and precision, are much circumscribed with regard to extension and improvement. Like man they derive advantages from experience. But the conclusions they draw from this source are always feeble and extremely limited. Neither do they possess the inestimable faculty of transmitting the know-

knowledge acquired by individuals from generation to generation. By means of their senses, they learn to distinguish their enemies, or hurtful objects, at a distance; and they know how to avoid them. Experience teaches them to discriminate objects of pleasure from those of pain; and they act according to the feelings excited by these objects. Some animals can even accommodate their instincts to particular circumstances and situations. The feelings of brutes are often more exquisite than ours. They have sensations; but their faculty of comparing them, or of forming ideas, is much circumscribed. A dog or a monkey can imitate some human actions, and are capable of receiving a certain degree of instruction. But their progress soon stops. Nature has fixed the boundaries of mental as well as of corporeal powers; and these boundaries are as various as the number of distinct species. Our wonder is equally excited by the sagacity of some animals, and by the stupidity of others. This gradation of mental faculties originates from the number or paucity of instincts bestowed on particular species, joined to the greater or smaller power of extending or modifying these instincts by experience and observation.

Man is endowed with a greater number of instincts than any other animal. The superiority of his rank, however, does not proceed from this source alone. Man enjoys beyond every other animal the faculty of extending, improving, and modifying the different instincts he has received from Nature. It is this faculty which enables him to compare his feelings, to form ideas, and to reason concerning both. The bee makes cells, and the beaver constructs habitations of clay. The order of their architecture, however, is invariably the same. Man likewise builds houses: But he is not forced, by an irresistible instinct, to work always on the same plan. His habitations, on the contrary, vary with the fancy of the individuals who design and construct them.

Upon the whole, the dignity of man's rank depends not upon the structure of his organs. It is from the powers of his intellect alone that he is entitled to claim a superiority over the brute creation. These powers enable him to form ideas, to abstract, to reason, to invent, and to reach all the heights of science and of art.

The remarks formerly made are applicable to quadrupeds in general. But, before
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concluding this branch of the subject, we shall point out a few peculiarities in the structure of particular species.

Beside the four stomachs common to ruminating animals, the camel and dromedary have a fifth bag, which serves them as a reservoir for holding water. This bag is capable of containing a very large quantity of that necessary element. When the camel is thirsty, and has occasion to macerate his dry food in the operation of ruminating, by a simple contraction of certain muscles, he makes part of this water ascend into his stomach, or even as high as the gullet. This singular construction enables him to travel six, eight, or even twelve days in the sandy deserts, without drinking, and to take at once a prodigious quantity of water, which remains in the reservoir pure and limpid; because neither the humours of the body, nor the juices that promote digestion, can have access to it. Beside this singularity of structure, the camel has two large fleshy bunches on his back, and the dromedary, or swift camel, one bunch; and the feet of both are covered with a very tough, but flexible substance. The conformation of these animals enables them to travel with heavy loads through the sandy deserts of the

East, where the horse or the ass would inevitably perish ; because Nature has not provided them with reservoirs for holding and preserving water, which are indispensable in countries where none of that element can be procured but in particular places, that are often distant many days journey from each other. When we consider the structure of the camel and dromedary, we cannot be deceived with regard to their destination. The four stomachs indicate a vegetable diet, and the same docility and gentleness of manners which characterise the whole ruminating tribes. From the addition of a fifth bag, or reservoir for the reception and preservation of water, we should expect to find some peculiarity of disposition. In this conjecture we are not deceived. Of all animals which man has subjugated, the camel and dromedary are the most abject slaves. With incredible patience and submission they traverse the burning sands of Africa and Arabia, carrying burdens of amazing weight. Instead of discovering symptoms of reluctance, they spontaneously lie down on their knees till their master binds the unmerciful load. Arabia, and some parts of Africa, are the driest and most barren countries in the world.

world. Both the constitution and structure of camels are nicely adapted to the soil and climate in which they are produced. The Arabians consider the camel as a gift sent from heaven, a sacred animal, without whose assistance they could neither subsist, traffic, nor travel. The milk of the camel is their common food. They also eat its flesh; and of its hair they make garments. In possession of their camels, the Arabs want nothing, and have nothing to fear. In one day they can perform a journey of fifty leagues into the desert, which cuts off every approach from their enemies. All the armies in the world would perish in pursuit of a troop of Arabs. An Arab, by the assistance of his camel, surmounts all the difficulties of a country which is neither covered with verdure, nor supplied with water. Notwithstanding the vigilance of his neighbours, and the superiority of their strength, he eludes their pursuit, and carries off, with impunity, all that he ravages from them. When about to undertake a depredatory expedition, an Arab makes his camels carry both his and their own provisions. When he reaches the confines of the desert, he robs the first passengers who come in his way, pillages the solitary houses, loads his camels with
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the booty, and, if pursued, he accelerates his retreat. On these occasions he displays his own talents as well as those of the camels. He mounts one of the fleetest, conducts the troop, and obliges them to travel day and night, without almost either stopping, eating, or drinking; and, in this manner, he often performs a journey of 300 leagues in eight days.

Another order of quadrupeds deserves our notice. Those which have been distinguished by the appellation of amphibious, are capable of remaining a long time under water. They live chiefly upon fishes, and, without this faculty of continuing a considerable time under water, they would be unable to procure their food. To this tribe belong the seal, the walrus, the manati, the sea-lion, &c. The seal and walrus are more nearly allied to land-quadrupeds than to the cetaceous animals; because they have four distinct legs, though nothing but the feet project beyond the skin. The toes of the feet are all connected by membranes, which enable these animals to swim in quest of their prey. They differ from terrestrial quadrupeds by the singular faculty of living with equal ease either in air or in water. This peculiarity of economy

mony and manners presupposes the necessity of some deviation from the general structure of quadrupeds; and Nature has accomplished this purpose by a very simple artifice.

In man, and in all quadrupeds, the lungs of the foetus have no motion, and receive no more blood than is requisite for their growth and nourishment. But, immediately after birth, the young animals respire, and the whole mass of blood circulates through their lungs. To carry on the circulation in the foetus state, another passage was necessary. The blood in the right auricle of the heart, instead of passing into the pulmonary artery, and, after circulating through the lungs, returning into the left auricle by the pulmonary vein, passes directly from the right to the left auricle through an aperture called the *foramen ovale*, which is situated in the partition of the heart that separates the cavities of the two auricles. By this contrivance, the mass of blood, without deviating into the lungs, enters the aorta, and is distributed over every part of the body. In man, and the other terrestrial animals, the foramen ovale of the heart, which permits the foetus to live without respiration, closes the moment after birth, and remains shut during life. Animals

mals of this construction can neither live without air, nor remain long under water, without being suffocated.

But, in the seal, walrus, and other amphibious animals, the foramen ovale continues open during life, though the mothers bring forth on land, and respiration commences immediately after birth. By means of this perpetual aperture in the septum or partition of the heart, which allows a direct communication of the blood from the vena cava to the aorta, these animals enjoy the privilege of respiring, or not, at their pleasure.

This singularity in the structure of the heart, and the consequent capacity of living equally on land and in water, must necessarily produce some peculiarities in the manners and dispositions of amphibious animals. The seal, accordingly, whose history is best known, may be considered as holding the empire of the silent ocean. To this dignity he is entitled by his voice, his figure, and his intelligence, which render him so superior to the fishes, that they seem to belong to another order of beings. Though his oeconomy be very different from that of our domestic animals, he is susceptible of a species of education. He is reared by putting him frequently

quently in water. He is taught to give a salute with his head and his voice. He approaches when called upon. His senses are equally acute as those of any quadruped; and, of course, his sensations and intellect are equally active. Both are exhibited in the gentleness of his manners, his social disposition, his affection for the female, his anxious attention to his offspring, and the expressive modulation of his voice. Besides, he enjoys advantages which are peculiar to him. He is neither afraid of cold nor of heat. He lives indifferently on herbs, flesh, or fish. He inhabits, without inconvenience, water, land, or ice. When assistance is necessary, the seals understand and mutually assist one another. The young distinguish their mother in the midst of a numerous troop. They know her voice; and, when she calls, they never fail to obey.

Before dismissing this branch of the subject, the elephant must not be passed over in silence. His structure is uncommon, and so are his talents. The elephant is the largest and most magnificent animal that at present treads the earth. Though he daily devours great quantities of herbage, leaves, and branches of trees, he has but one stomach, and
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does not ruminate. This want, however, is supplied by the magnitude and length of his intestines, and particularly of the colon, which is two or three feet in diameter by fifteen or twenty in length. In proportion to the size of the elephant, his eyes are very small; but they are lively, brilliant, and capable of pathetic expression of sentiment. He turns them slowly, and with mildness toward his master. When he speaks, the animal regards him with an eye of friendship and attention. He seems to reflect with deliberation, and never determines till he has examined, without passion or precipitation, the orders which he is desired to obey. The dog, whose eyes are very expressive, is too prompt and vivacious to allow us to distinguish with ease the successive shades of his sensations. But, as the elephant is naturally grave and moderate, we perceive in his eyes the order and succession of his thoughts. His ears are very large, and much longer, even in proportion to his body, than those of the ass. They lie flat on the head, and are commonly pendulous; but he can raise and move them with such facility, that he uses them as a fan to cool himself, and to defend his eyes from dust and insects. His ear is likewise remarkably fine; for he
delights

delights in the sound of musical instruments, and moves in cadence to the trumpet and tabour.

But, in the structure of the elephant, the most singular organ is his trunk or proboscis. It is composed of membranes, nerves, and muscles; and it is at once an instrument of feeling and of motion. The animal can not only move and bend the trunk, but he can contract, lengthen, and turn it on all sides. The extremity of the trunk terminates in a protuberance that stretches out on the upper side in the form of a finger; by means of which he lifts from the ground the smallest pieces of money; he selects herbs and flowers, and picks them up one by one; he unties the knots of ropes, opens and shuts gates by turning the keys or pushing back the bolts. In the middle of this protuberance or finger, there is a cavity in the form of a cup, and, in the bottom of the cup are the apertures of the two organs of smelling and respiration. This hand of the elephant possesses several advantages over that of the human. It is more flexible, and equally dexterous in laying hold of objects. Besides, he has his nose in his hand, and is enabled to combine the power of his lungs with the action of his finger,

ger, and to attract fluids by a strong suction, or to raise heavy bodies by applying to them the edge of his trunk, and making a vacuum within by a vigorous inspiration. Hence delicacy of feeling, acuteness of smelling, facility of movement, and the power of suction, are united at the extremity of the elephant's trunk. Of all the instruments which Nature has bestowed on her most favourite productions, the trunk of the elephant seems to be the most complete, as well as the most admirable. It is not only an organic instrument, but a triple sense, whose united functions exhibit the effects of that wonderful sagacity which exalts the elephant above all other quadrupeds. He is not so subject, as some other animals, to errors of vision; because he quickly rectifies them by the sense of touch; and, by using his trunk as a long arm, for the purpose of touching remote objects, he acquires, like man, clear ideas of distances. But other animals, except such as have a kind of arms and hands, can only acquire ideas of distances by traversing space with their bodies. Delicacy of feeling, the flexibility of the trunk, the power of suction, the sense of smelling, and the length of the arm, convey ideas of the substance of bodies, of their external

ternal form, of their weight, of their salutary or noxious qualities, and of their distances. Thus, by the same organs, and by a simultaneous act, the elephant feels, perceives, and judges of several things at one time. It is by virtue of this combination of senses and faculties in the trunk that the elephant is enabled to perform so many wonderful actions, notwithstanding the enormity of his mass and the disproportions of his form. The thickness and rigidity of his body; the shortness and stiffness of his neck; the smallness of his head; the largeness of his ears, nose, and tusks; the minuteness of his eyes, mouth, genitals, and tail; his straight, clumsy, and almost inflexible limbs; the shortness and smallness of his feet; the thickness and callosity of his skin; all these deformities are the more obvious and disagreeable, because they are modelled on a large scale, and most of them are peculiar to the elephant.

From this singular conformation, the animal is subjected to many inconveniencies. He moves his head with difficulty, and cannot turn back without making a large circuit. For this reason, the hunters attack him behind, or on the flanks, and avoid the effects of his rage by circular movements. He cannot

not seize any object on the ground with his mouth, because his neck is too stiff to allow his head to reach the earth. He is therefore obliged to lay hold of his food, and even of his drink, with his nose, and then convey them to his mouth. It is likewise a consequence of this structure, that the young elephants are said to suck with their nose, and afterwards pour the milk into their gullet.

OF THE STRUCTURE OF BIRDS.

From the figure and movements of the feathered tribes, we should be led to imagine that the structure of their organs was extremely different from that of quadrupeds. Their oeconomy and manner of living required some variations in their frame. But those variations are by no means so many or so great as might be expected. Instead of hairs, their bodies are covered with feathers, which, beside the beautiful variety of their colours, protect this class of animals from the assaults of rain and cold. They have only a couple of legs; but Nature has furnished them with two additional instruments of motion, by which they are enabled to rise from the surface of the earth, and to fly with amazing rapidity through the air. The wings are articulated

articulated with the breast-bone, and their motions are performed by muscles of remarkable strength. Many birds are continually passing through hedges and thickets. To defend their eyes, therefore, from external injuries, as well as from too much light when flying in opposition to the rays of the sun, they are furnished with a membrane called *membrana nictitans*, which, like a curtain, can at pleasure be drawn over the whole eye. This covering is neither opaque nor pellucid; but, being somewhat transparent, it allows as many rays to enter as render any object just visible, and enable them to direct their progress through the air. It is by the instrumentality of this membrane that the eagle looks at the sun. The feathers of all birds are inserted into the skin in such a manner that they naturally lie backward from the head; and allow the rain to run off their bodies, and, by turning their heads in opposition to the wind, prevent the wind from rumpling their feathers and retarding their flight. Beside this provision, the rump of birds terminates in a large gland, which secretes an oily substance. When the feathers are too dry, or any way disordered, the animals squeeze this gland with their bills, extract

tract the oil, and with it they besmear and dress the feathers. By this means the admission of water is totally prevented. Birds have no separate ribs; but the breast-bone, which is very large, joins the back-bone, and supplies their place.

With regard to the external figure of birds, the form of their bodies is nicely adapted to their manners and the mode of life they are destined to pursue. By striking the air with their wings, they move forward in that element, and their tail serves them as a rudder to direct their course. Their breast-bone, instead of being flat, rises gradually from the spine and terminates in a sharp ridge or keel, which enables them to cut the air with greater facility. For the same purpose, the heads of birds are proportionally smaller than those of quadrupeds, and most of them terminate in light sharp-pointed beaks. They are likewise deprived of external ears, and of protuberant nostrils. Their tails, instead of vertebrae, muscles, and skin, consist entirely of feathers. They have no pendulous scrotum, no bladder, no fleshy uterus. Neither have they an epiglottis, though many of them possess great powers of modulation, and some of them may even be taught to articulate words.

words. To lighten their beaks, they are deprived of lips and teeth; and their abdomen or belly is proportionally small and narrow.

From this general view of the external figure and structure of birds, it is apparent, that Nature has designed them for two distinct kinds of motion. They can, at pleasure, either walk on the surface of the earth, or mount aloft, and penetrate the airy regions with prodigious swiftness.

Some peculiarities in the internal structure of birds deserve our notice.

Like quadrupeds, the feathered tribes are divided into granivorous and carnivorous; and their manners and dispositions correspond with their internal and external conformation.

In the granivorous class, the oesophagus or gullet runs down the neck, and terminates in a pretty large membranous sac, called the *ingluvies*, or craw, where the food is macerated, and partly dissolved by a liquor secreted from glands spread over the surface of this sac. Some birds, as the rooks and the pigeon kind, have the power of bringing up the food from this sac into their mouths, and feeding their young with it in a half digested form. After macerating for some time,

the food passes through the remainder of the gullet into another species of stomach denominated *ventriculus succenturiatus* which is a continuation of the gullet. Here the food receives a farther dilution. From this second stomach, the food is transmitted to the gizzard, or true stomach, which consists of two very strong muscles, covered externally with a tendinous substance, and lined with a thick, firm membrane. The remarkable strength of the gizzard was formerly supposed to assist the digestion of granivorous birds by attrition. But this notion has of late been entirely exploded; for Doctor Stevens, and, after him, Spalanzani, have demonstrated, by unequivocal experiments, that digestion is performed solely by the dissolving powers of the gastric juices*. The other intestines are proportionally larger, and much longer than those of the carnivorous birds.

The structure of the heart, in granivorous birds, is nearly the same with that of quadrupeds.

The lungs hang not loose in the cavity of the thorax, but are fixed to the back-bone:

* See Stevens' Dissert. Med. Inaug. De Alimentorum Concoctione, Edin. 1777, and Spalanzani.

Neither are they divided into lobes, as in man and other animals, whose spines admit of considerable motion. They are red, spongy bodies, covered with a membrane that is pervious, and communicates with the large vesicles or air-bags which are spread over the whole abdomen. These vesicles, when distended with air, render the bodies of birds specifically light. They likewise supply the place of a diaphragm, and strong abdominal muscles. They produce the same effects on the viscera as these muscles would have done, without the inconveniency of giving an additional weight to the body.

Birds have no bladder of urine: But a bluish-coloured canal, or ureter, is sent off from each kidney, and terminates in the rectum. Their urine is discharged along with the faeces. It is a whitish substance, and turns chalkey when exposed to the air.

The testicles of the male are situated on each side of the back-bone, and are very large in proportion to the size of the animal. From the testicles proceed two feminal ducts, which at first are straight, but afterwards acquire a convoluted form, as in the epidydymus of man. These ducts terminate in the penis, of which the cock has two, one on each side of the common cloaca. They are very

small and short; and from this circumstance, they long escaped the notice of anatomists.

In the female, the cluster of yolks, being analogous to the human ovaria, are attached to the back-bone by a membrane. This membrane is very thin, and continues down to the uterus. The yolk, after separating from its stalk, passes into a canal called the *infundibulum*, where it receives a gelatinous liquor, which, with what it farther acquires in the uterus, composes the white of the egg. The uterus is a large bag, situated at the end of the *infundibulum*, and is full of wrinkles on the inside. Here the egg receives its last covering, or shell, and is pushed out of the vagina at an aperture placed immediately above the anus.

From this description of the structure of granivorous birds, the analogy between them and the herbivorous quadrupeds is conspicuous. In both, the number of their stomachs, the length and capacity of their intestines, and the quality of their food, are very similar. But this analogy is not confined to structure and organs: It extends to manners and dispositions. Like the herbivorous quadrupeds, this order of birds are distinguished by the gentleness and complacency of their tempers.

pers. Contented with the seeds of plants, or small insects, the stronger never wage war with the weaker. Their chief attention is occupied in procuring food, in hatching and rearing their young; and their vigilance is kept perpetually active in eluding the snares of men and other rapacious animals. The whole are a timid race, and many of them are so tractable that they may easily be rendered domestic. Man, accordingly, ever attentive to his interest, has not failed to derive advantage from the innocence and stupidity of these animals. Of the gallinaceous and duck kind, which are the most prolific, and consequently the most profitable, he has chiefly selected the hen, the goose, the duck, the turkey, and the peacock. In this selection he has discovered his sagacity; for, instead of pairing, these birds are polygamous, one male being sufficient to fertilize a number of females, which is a great saving in the article of food.

With regard to carnivorous birds, their general conformation is nearly the same with those of the granivorous kind. They have the same number of stomachs; but all of them are smaller and weaker. Their intestines are also much shorter. To enable them

them to procure food, they are obliged to fly quickly, and continue long on the wing. Their wings, accordingly, are proportionally longer, and they have more strength in their muscles. For the purpose of seizing and devouring prey, Nature has bestowed on them strong hooked bills, and long sharp claws or pounces. They have also large heads, short necks, strong brawny thighs, and sharp-sighted eyes.

Like rapacious quadrupeds, birds of prey are capable of enduring hunger for a great length of time. This faculty is, perhaps, acquired partly by habit; because the obtaining of their food is often very precarious. The females are larger, stronger, and more beautiful both in shape and plumage, than the males. For this reason, the male hawks are called *tercels*, or *thirds*, because they are supposed to be one third less than the females. Nature seems to have bestowed this superiority of size and strength upon the female, because she is obliged to procure food both for herself and for her progeny.

The analogy between the structure of rapacious birds and carnivorous quadrupeds is obvious. Both of them are provided with weapons which indicate destruction and rapine.

pine. Their manners, are also fierce and unsocial. They never, if the vulture be excepted, herd together in flocks, like the inoffensive granivorous tribes. When not on the wing, they conceal themselves on the tops of sequestered rocks, or in the depths of the forests, where they spend their time in sullen solitude. Those of them which feed upon carion, as the raven, have the sense of smelling so acute, that they scent dead carcases at amazing distances.

Beside these great divisions of birds into granivorous and rapacious, whose manners and dispositions perfectly coincide with the structure of their bodies, there are other tribes to whom nature has given peculiar organs. In all these deviations from the common structure, a singularity in the mode of living, and the oeconomy of the animal, is the inviolable result.

Like the amphibious animals, a number of fowls live chiefly in the water, and feed upon fishes and aquatic insects. To enable them to swim and to dive in quest of food, their toes are connected together by broad membranes or webs. By stretching their toes, and striking the water backward with these webs, their bodies are moved forward, and they

they employ their tail as a rudder to direct their course. Without these additional instruments, fowls could not swim; and, accordingly, such birds as are not provided with webs never take to the water. But those furnished with webs have such a strong propensity to water, that, when restrained from their favourite element, they discover the greatest uneasiness, and, when their liberty is restored, they fly in a direct course either to the sea, a river, or a lake.

There is another tribe of aquatic birds, some of which feed upon fishes and insects, and others live principally by sucking certain juices from mud. Both these kinds frequent marshy places, or the margins of lakes and rivers. They do not swim, but wade, in quest of food. This singularity in their manners required a correspondent variation in their form and structure. To enable them to wade in waters and in mires, Nature has provided them with long legs, naked of feathers for a considerable space above the knees. Their toes are not, like those of the swimmers, connected by continued membranous webs. Most of them have likewise very long necks and bills, to enable them to search for and apprehend their food. To these tribes
belong

belong the crane, the herons, the bittern or miredrum, the stork, the spoon-bill, the woodcock, the snipe, and many other species.

Having given a general idea of the structure and oeconomy of birds, we shall next make a few remarks on the form and manners of fishes.

OF THE STRUCTURE AND ORGANS OF FISHES.

It is one great and benevolent intention of Nature, that no part of the universe should be deprived of inhabitants. The earth, the air, the waters, are full of living beings, who are not only conscious of their existence, but enjoy degrees of happiness proportioned to their natures, and the purposes they are destined to answer in the general scale of animation. The different elements in which they live necessarily required a variety in their form, their food, and their manners. The inhabitants of the earth and air have already been partially described: Those of the waters are next to be considered.

The bodies of most fishes are covered with a strong, thick, skin, in which numberless scales are inserted in an imbricated form, or like tiles on the roofs of houses. Many of them

them, and particularly those which are shaped like the cod, the trout, and the haddock, have a longitudinal line on each side. In these lines there are a number of small ducts or apertures, which throw out a mucous substance that lubricates their skins, and seems to answer the same purposes as the mucous glands or ducts placed in most of our internal organs.

Fishes are destitute of hands and feet. Their progressive motion, therefore, is performed in a manner different from that of quadrupeds and birds. Their instruments of motion are fins, or machines consisting of a number of elastic beams, connected to one another by firm membranes. Their tails are of the same texture. Their spine is remarkably flexible toward the posterior part of the body, and here the strongest muscles are likewise inserted. They have a power of contracting and dilating their tails at pleasure; by which means, and by the assistance of the fins, they move forward in the same manner as a boat with oars on its sides and a rudder at its stern. Fishes have no neck: As they seek their food in a horizontal position, and can move their bodies either upward or downward;

ward, a long neck would necessarily have impeded their motion through the water.

The form of fishes is extremely various; and, if their history were sufficiently known, the connection between their structure and their manners would be equally apparent as in the other tribes with which we are better acquainted. Some fishes are long and cylindrical, as the sea-serpent, and all the eel-shaped species. The eel-kind, from their figure, are enabled to trail their bodies along the bottom, and to conceal themselves below the sand or mud. Others are less cylindrical, and proportionally shorter, as the mackerel, the cod, the herring, the salmon, &c. These, from the number and position of their fins, as well as from the shape of their bodies, are destined for quicker motion, and for travelling to great distances in quest of food, or for spawning in shoals or in rivers. Others, as the flounder, the skate, the turbot, torpedo, &c. are broad, and compressed. These, like the eel-kind, frequent muddy bottoms. Others are triangular, quadrangular; round, &c. Besides those which approach to regular figures, the variations and compositions are so numerous, that the forms of fishes are much more diversified than those of quadrupeds

peda or birds. To defend themselves against their enemies, many fishes are armed with strong, sharp spines or prickles. For the same purpose, and likewise for wounding or killing their prey, some have a large horn on their front, and others a sword, or rather a saw, which are tremendous weapons. The more timid and defenceless tribes are endowed with the faculty of rapid motion; and some of them have fins so large and flexible, that, when hard pursued, they are enabled to leave their natural element, to dart through the air to considerable distances, and disappoint the designs of their enemies.

Fishes are as much diversified in size as in figure. The ocean produces the largest animals which now inhabit this globe. The enormous masses of the whale and walrus tribes far exceed those of the elephant, rhinoceros, or river-horse, the largest terrestrial animals of which we have any proper knowledge. From the immense bones, however, found in Siberia and many parts of Europe, we are induced to believe, that land animals have formerly existed whose size must have been much larger than that of the present elephant. This animal, whose species is now supposed to be extinguished, is known among
natu-

naturalists by the denomination of the *mammoth*. Near the river Ohio, some prodigious bones and teeth have lately been discovered, which indicate an animal of incredible magnitude.

With regard to internal structure, fishes, like land-animals, are furnished with a backbone and ribs, which run from the head to the tail. To these, the bones of the head, and the fins, all the muscles and instruments of motion, are attached.

The mouths of most fishes are furnished with teeth; but in some, as the mullet, sturgeon, &c. the teeth are wanting. In some, the teeth are situated on the jaw-bones, in others, on the tongue and palate. The teeth of fishes are principally designed for laying hold of and detaining their prey, which they generally swallow entire. For this purpose, the teeth are commonly ferrated, or bent inward, like tenter-hooks. By this structure, small fishes are easily forced downwards, and their return is at the same time prevented.

In fishes, the organ of smelling is large; and they have a power of contracting and dilating, at pleasure, the entry into their nose.

It was formerly doubted whether fishes were endowed with the sense of hearing.

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But that doubt is now fully removed; because it has been found, that, like other animals, they have a compleat organ of hearing, and that water is a proper medium for the conveyance of sound. Besides, in the skate, and some other genera, the learned and ingenious Dr. Monro, Professor of Anatomy in the College of Edinburgh, has lately discovered an aperture which leads directly to the internal parts of the ear.

The gullet of fishes is so short that it is hardly to be distinguished from the stomach, which is of an oblong figure. The guts are very short, making only three convolutions, the last of which terminates in the common vent for the faeces, urine, and semen. From this structure of the stomach and intestines, analogy would lead us to conclude, that fishes live chiefly upon animal food. Experience, accordingly, teaches us, that almost all fishes prey upon the smaller kinds, and even devour their own young. The liver is proportionally large, of a whitish colour, and situated on the left side. The gall-bladder lies at a considerable distance from the liver, and discharges the gall into the gut. In fishes, the organs of generation are two bags situated in the abdomen, and uniting near the anus. In
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the male, these bags are filled with a thick whitish substance called the *milt*, and in the female with an infinite number of minute eggs called the *roe*. At the season of spawning, the bags of both male and female are greatly distended; but, at other times, the male organs can scarcely be distinguished from those of the female.

The swimming bladder is an oblong, white, membranous bag, which contains nothing but a quantity of elastic air. It lies close to the back-bone, and has a pretty strong muscular coat. By contracting this coat, and, of course, condensing the air it contains, some fishes are enabled to render their bodies specifically heavier than water, and to sink to the bottom; and, when the muscular fibres cease to act, the air dilates, and makes their bodies specifically lighter. By this curious piece of mechanism, the animals have the power of sinking to the bottom, or of rising to the surface. According to the different degrees of contraction and dilatation of this bladder, fishes can, at pleasure, keep themselves higher or lower in the water. Hence flounders, soles, skate, and other fishes which have no swimming bladder, always grovel at or near the bottom. It is likewise a consequence of
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the relaxation of this bladder, that dead fishes which are furnished with it uniformly rise to the surface. The air-bag, in some fishes, communicates, by a duct, with the gullet, and, in others, with the stomach. At the upper end of the air-bag, there are red-coloured glandular bodies connected with the kidneys. From the kidneys the ureters proceed downward to their insertion in the urinary bladder, which lies in the lower part of the abdomen, and the urethra terminates in the anus.

Fishes have a membranous diaphragm, or midriff, that forms a sack in which the heart is contained. The heart is of a triangular figure. It has only one auricle, one ventricle, and one great artery. This artery, instead of supplying all the parts of the body, as in the frog, is distributed entirely on the gills. All the branches terminate there, and become at last so small that they escape the naked eye. The branchiae, or gills, lie in two large slits on each side of the head, and are analogous to the lungs of land-animals. The figure of the gills is semicircular, and on each side of them are immense numbers of fibrils resembling fringes. The gills are perpetually subjected to an alternate motion from
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the pressure of the water and the action of the muscles. They are covered with a large flap, which allows an exit to the water necessarily taken in by the animals every time their mouths are opened. The blood is again collected by a vast number of small veins, which, instead of going back a second time to the heart, immediately unite, and form an aorta descendens, which sends off branches to supply all the parts of the body, except the gills. From the extremities of these branches the blood is collected by veins, and returned to the heart nearly in the same manner as in other animals.

The organs by which the nutritious part of the food of fishes are extracted and conveyed to the general mass of blood, and known by the names of lacteal, absorbent, and lymphatic vessels, are so analogous to those of men and quadrupeds, that it is unnecessary to describe them. For the same reason, no description shall be given of the nerves, which, as in other animals, proceed from the brain and spinal marrow, and are distributed over every part of the body.

Having finished this sketch of the structure and organs of fishes, it is almost needless to remark, that, though they live in a different

element, and vary greatly from land-animals in figure, Nature, in the formation of their bodies, in the mode of their nutrition, respiration, and sensation, has acted upon the same great and general plan.

We are now to take a view of the structure of insects, a numerous class of animals, most of whom recede farther from the common mode of animal organization than any of the other classes.

OF THE STRUCTURE OF INSECTS.

In the first chapter, a few observations were made concerning the structure and organs of insects, in order to show more clearly the analogies between animals and vegetables. These it is unnecessary to repeat. We shall therefore proceed to a more particular examination of the structure of insects, and to trace the connection between that and their manners.

Insects exhibit such an immense variety in figure, colour, and disposition of parts, that Naturalists have found it necessary to arrange them into different tribes or families. These tribes are distinguished from one another by certain peculiarities in the structure of their bodies.

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The most general division of insects is derived from the circumstance of their having or wanting wings, and from the number and substances of which these instruments of motion are composed. They are distinguished from all other animals by many peculiarities of form. None of the other classes have more legs than four. But most insects have six; and many of them have eight, ten, fourteen, sixteen, eighteen, and even a hundred, legs. Beside the number of legs, insects are furnished with antennae or feelers. These feelers, by which insects grope and examine the substances they meet with, are composed of a great number of articulations or joints. Linnaeus, and other Naturalists, maintain, that the uses of these feelers are totally unknown. But the slightest attention to the manner in which some insects employ their feelers will satisfy us of at least one use they derive from these organs. When a wingless insect is placed at the end of a twig, or in any situation where it meets with a vacuity, it moves the feelers backward and forward, elevates, depresses, and bends them from side to side, and will not advance farther, lest it should fall. Place a stick, or any other substance, within reach of the feelers; the animal im-

mediately applies them to this new object, examines whether it is sufficient to support the weight of its body, and instantly proceeds in its journey. Though most insects are provided with eyes, yet the lenses of which they consist are so small and convex, that they can see distinctly but at small distances, and, of course, must be very incompetent judges of the vicinity or remoteness of objects. To remedy this defect, insects are provided with feelers, which are perpetually in motion while the animals walk. By the same instruments, they are enabled to walk with safety in the dark.

No other animals but the insect tribes have more than two eyes. Some of them have four, as the phalangium; others, as the spider and scorpion, have eight eyes. In a few insects, the eyes are smooth; in all the others, they are hemispherical, and consist of many thousand distinct lenses. The eyes are absolutely immovable: But this defect is supplied by the vast number of lenses, which, from the diversity of their positions, are capable of viewing objects in every direction. By the smallness and convexity of these lenses, which produce the same effect as the object glass of a microscope, insects are enabled to see bodies

dies that are too minute to be perceived by the human eye.

Another peculiarity deserves our notice. No animal, except a numerous tribe of four-winged insects, have more than two wings.

With regard to sex, quadrupeds, birds, and fishes, are distinguished into males and females. But the bee and the ant furnish examples of neuters, which are absolutely barren: And the earth-worm, and several shell insects, are hermaphrodite, each individual possessing the prolific powers of both male and female.

It is likewise remarkable, that all winged insects undergo three metamorphoses or changes of form; The egg is discharged from the body of the female in the same manner as in other oviparous animals. By a wonderful instinct, these seemingly stupid creatures uniformly deposit their eggs on such animal or vegetable substances as furnish proper food for the worm or caterpillar, that is to be hatched by the heat of the sun. The worm or caterpillar is the first state. The bodies of caterpillars are soft and moist. They have no wings, and are totally deprived of the faculty of generation. After continuing for some time in this reptile state, they are transformed

formed into a chrysalis, which is drier and harder than the caterpillar. The chrysaes of some insects are naked, and those of others are covered with a filken web, spun by the animals before their change is completed. In this state, many of them lie motionless, and seemingly inanimate, during the whole winter. When the spring or summer heats return, they burst from their last prison, and, from vile reptiles, are transformed into beautiful flies. In this perfect state they are exceedingly active, fly about in quest of their mates, and after propagating their species, the females deposit their eggs, and the same circle of animation and change perpetually goes round. Hence the structure and figure of the same individual animals are threefold, which renders the knowledge of insects extremely complicated, as we must be acquainted with them in the several forms they successively assume.

There is another peculiarity in the structure of insects. They are deprived of bones. But that defect is supplied, in some, by a membranous or muscular skin, and, in others, by a crustaceous or horny covering. In this circumstance, insects resemble the shell-animals

mals, whose bones constitute the external parts of their bodies.

In general, the bodies of insects are composed of a head, trunk, and abdomen. The head is commonly attached to the trunk by a joint or articulation. Beside eyes, feelers, and mouth, the heads of some insects are furnished with *palpi* fixed to the mouth; and they are either four or six in number. Each of them consists of two, three, or four joints, and are often mistaken for the antennae or feelers. These instruments seem to serve the animals instead of hands; for they employ the palpi to bring the food to their mouths, and to keep it steady while eating. It is asserted by Linnaeus, and other Naturalists, that the heads of insects are destitute of brains, nostrils, and ears. The minuteness of the animals under consideration may have hitherto prevented us from distinguishing these organs. If they want a brain, it is certain that their sense of seeing is acute; and we know that they are amply supplied with nerves, which produce the same effects as the brain in larger animals. If they are deprived of nostrils, the slightest attention must convince us, that some of them possess the sense of smelling in a very high degree. Upon any other supposition,
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how should the different species of flies, the moment they escape from the chrysalis state, distinguish, and directly approach, the different animal and vegetable substances Nature has destined for their respective nourishment? A piece of meat is no sooner exposed to the air than it is covered with flesh flies, upon which they both feed and deposit their eggs. Without this sense, how should wasps, and other flies, be allured from considerable distances into bottles encrusted with honey or molasses? These, and similar actions, cannot be effects of sight; for the distance, the minuteness, and frequently the position of the food, render it impossible for the eye to discover those substances to which they instantly resort.

With regard to hearing, it is more difficult to determine whether insects be endowed with this sense. We can judge of it, not by the knife of the Anatomist, but by the affections and motions of the animals themselves. Several trials I have made on house-flies incline me to think that these animals possess a sense of a nature similar, at least, to that of hearing. At the distance of three or four feet, a smart stroke, even upon a stone wall, alarms and puts them to flight. But this may partly

ly be attributed to the vibration in the wall, or the concussion of the air, produced by the stroke. To obviate this difficulty, at the same distance of between three and four feet, I struck the air repeatedly with a bookbinder's folder, without giving the smallest alarm to the flies. But, when I struck the folder against the boards of a book, which I held in my hand, and made a smart noise, the animals were instantly alarmed, and flew off at the second stroke. The same effect is produced in a room just light enough to render the animals visible. These trials, which I have often repeated, seem to indicate that flies, if they are really deprived of ears, are endowed with an analogous sense, though we are ignorant of its situation.

Naturalists have limited the senses of insects to those of seeing and feeling. But the above remarks render it more than probable that flies possess likewise the senses of smelling and of hearing: Neither should the sense of taste be denied them; for, though they may be assisted by smelling to discover and select their food, we cannot suppose that Nature has denied them the pleasure which other animals so universally derive from eating. Besides, an agreeable sensation, similar to

to that of taste, must accompany an action which removes the pain arising from hunger.

The mouth of insects is generally placed in the under part of the head; but, in some, it is situated in the breast. The jaws, instead of being horizontal, are often transverse, and furnished with teeth. The greater number of winged insects are provided with a proboscis or trunk, an instrument by which they extract the juices from animal or vegetable substances. The proboscis of insects is a machine of a very complicated nature. In butterflies, the proboscis is situated precisely between the two eyes. Though some of them exceed three inches in length, they occupy but a small space. When a butterfly is not in quest of food, the proboscis is rolled up in a spiral form, similar to that of a watch-spring, each successive ring covering the one which precedes. The substance of the proboscis has some resemblance to that of horn. It tapers from the base to the extremity. It is composed of two similar and equal parts, each of which is concave, and, when joined, form three distinct tubes. Reaumur has rendered it probable, that these tubes enable the animals to extract the juices of plants, to conduct air into their bodies, and to convey the sensa-

sensation of smelling. Hence the proboscis of insects is an instrument which serves them for a mouth, a nose, and a wind-pipe.

The upper part of the trunk or body of insects is called the thorax, and the under part the abdomen or belly. The abdomen contains the stomach and other viscera. It consists of several rings or segments, and is perforated with spiracula, or tubes, which supply the want of lungs. The abdomen is terminated by the tail, which, in some insects, is armed with a sting, a forceps, a bristle, or a kind of claw with a moveable thumb.

The legs are composed of three parts, connected to each other by joints, and represent the thighs, shanks, ankles, and feet of larger animals.

The wings of insects are so diversified in number, consistence, and colour, that Linnaeus has made them the foundation of the several orders or divisions into which he divides this numerous class of animals. Some insects are furnished with four, and others with two wings, and some of them are entirely destitute of these instruments of motion.

The four-winged insects are arranged into five orders. The *first* order Linnaeus distinguishes by the name of *coleoptera*, or those insects

sects whose upper pair of wings consist of a hard, crustaceous, or horny substance. These cover and defend the under pair, which are of a more soft and flexible texture. This order comprehends the whole of what is properly called *scarabaei*, or the beetle tribe. Like other winged insects, all the beetles live for some time in the form of caterpillars, or grubs:

As a farther confirmation of the connection of manners with form and structure, it is here worthy of remark, that the same animals, when in the state of caterpillars, live in a different manner, and feed on substances of a very different kind from those they consume after their transformation into flies. The caterpillars of the garden-beetle, cockchafer, &c. lead a solitary life under ground, and consume the roots of plants. Those of others feed upon putrid carcases, every kind of flesh, dried skins, rotten wood, the dung of men and quadrupeds, and the small insects called *pucerons*, or *vine-fretters*. The devourers of the puceron contribute to cure such plants as happen to be infected with the *phthiriasis*, or lousy disease. But, after their transformation into flies, many of the same animals, which formerly fed upon dung and
putrid

putrid carcases, are nourished by the purest nectareous juices extracted from fruits and flowers. The creatures themselves, with regard to what may be termed *individual animation*, have suffered no alteration. But the fabric of their bodies, their instruments of motion, and the organs by which they take their food, are materially changed. This change of structure, though the animals retain their identity, produces the greatest diversity in their manners, their oeconomy, and the powers of their bodies. In the caterpillar state, these animals are extremely voracious, and, in many instances, acquire a greater magnitude than they possess after transformation; but they are incapable of multiplying their species, and of receiving nourishment from the same kinds of food. Besides, many caterpillars, previous to their transformation, live even in a different element. The ephemeron fly, when in the caterpillar state, lives no less than three years in the water, and extracts its nourishment from earth and clay. After transformation, this animal seldom exists longer than one day, during which the species is propagated, and myriads of eggs are deposited on the surface of the water.

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These eggs produce worms or caterpillars, and the same process goes perpetually round.

Linnaeus's *second* order of insects, or *hemiptera*, have likewise four wings. But the upper pair, instead of being hard and horny, rather resemble fine vellum. They cover the body horizontally; and do not meet in a direct line, forming a ridge or future, as in the beetle tribe. The whole of this order are furnished with a proboscis or trunk for extracting their food.

This order comprehends several genera or kinds, some of which we shall mention in a cursory manner.—The *blatta*, or *cock-roach*, is an animal which avoids the light, and is particularly fond of meal, bread, putrid bodies, and the roots of plants. It frequents bakers shops and cellars, and flies the approach of danger with great swiftness.—The head of the *mantis*, or *camel-cricket*, appears, from its continual nodding motion, to be slightly attached to the thorax. This insect is regarded by the Africans as a sacred animal; because it frequently assumes a praying or supplicating posture, by resting on its hind feet, and elevating and folding the first pair.—The *gryllus* comprehends a number of species, some of which are called *grasshoppers*, others *locusts*,
and

and others *crickets*. The *larvae*, or caterpillars of the *grylli*, have a great resemblance to the perfect insects, and, in general, live under ground. Many of these insects feed upon the leaves of plants. Others, which live in houses, prefer bread, and every kind of farinaceous substance.—The *fulgora*, or fire-fly: The foreheads of several of this genus, especially of those that inhabit China, and other hot climates, emit a very lively shining light during the night, which often alarms those who are unacquainted with the cause of the appearance.—The *cicada*, *frog hopper*, or *flea locust*: The *larvae*, or caterpillars, of some of this genus, discharge a kind of froth or saliva from the anus and pores of the body, under which they conceal themselves from the rapacity of birds and other enemies.—The *papa* or *water scorpion*, frequents stagnant waters. It lives chiefly on aquatic insects, and is exceedingly voracious.—The *cimex* or bug: Many species of this genus feed upon the juices of plants, and others upon the blood of animals. Some of them are found in waters, and others frequent houses, among which, though it wants wings, is the bed-bug, a pestiferous insect, which is too well known, and too generally diffused. The bugs differ from other insects

insects by their softness; and most of them emit a very foetid smell.—The *aphis*, *puceron*, or *vine-fretter*: These insects are very common, and are generally termed the *lice* of the plants which they infect: The *puceron*, as remarked in the first chapter, is viviparous in summer, and oviparous in autumn. Numbers of them are devoured by the ants, on account, as is supposed, of a sweet liquor with which their bodies are perpetually moistened.—*Chermes*: The *larvae* or caterpillars of this insect have six feet, and are generally covered with a hairy or woolly substance. The winged insects leap or spring with great agility, and infect a number of different trees and plants: The females, by means of a tube at the termination of their bodies, insert their eggs under the surface of the leaves, and the worms, when hatched, give rise to those tubercles, or galls, with which the leaves of the ash, the fir, and other trees, are sometimes almost entirely covered.

The *third* order or tribe of four-winged insects consists of three genera only. But the species comprehended under them are exceedingly numerous. All butterflies and moths belong to this order. Their wings are covered with a farinaceous powder, or rather with a kind of
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of scales or feathers, disposed in regular rows, nearly in the same manner as tiles are laid upon the roofs of houses. The elegance, the beauty, the variety of colours exhibited in their wings, are produced by the disposition and different tinctures of these minute feathers. The insects of this order, on account of their beauty and easy preservation, have always been the favourites of collectors, and particularly of those of the female sex. When the feathers are rubbed off, the wings appear to be nothing more than a naked, and often a transparent membrane. The feelers of the *papilio*, or *butterfly*, are thickest at their extremity, and often terminate in a kind of capitulum, or head. Their wings, when sitting, or at rest, are erect, their extremities join each other above the body, and the animals fly about, in quest of food and of their mates, during the day.—The *moths* are divided into two genera, the one called *sphinx*, or *hawk moth*, and the other *phalaena*, or *moth*. The feelers of the *sphinx* are thicker in the middle than at the extremities, and their form, in some measure, resembles that of a prism. The wings are, in general, deflected, their outer margins declining toward the sides. They fly about early in the morning,

and after sun-set; and, by means of their proboscis, like the butterflies, they suck the juices of plants.—The *phalaena*, or *moth*: The feelers of this genus are setaceous, and taper from the base to the point. When at rest, their wings are commonly deflected; and they fly during the night. Previous to their transformation, the caterpillars of the whole of this genus spin webs for covering and protecting the animals while in the chrysalis state. From a species of this tribe mankind have derived one of the greatest articles of luxury and of commerce which now exists in the world. That seemingly contemptible, that disgusting reptile known by the appellation of the *silk-worm*, in its passage from the caterpillar to the chrysalis state, produces those splendid materials which adorn the thrones of Princes, and add dignity and lustre to female beauty*.

The wings of the *fourth* order, distinguished by the name of *neuroptera*, are membranaceous, naked, and so interspersed with delicate veins, that they have the appearance of beautiful net-work. Their tail has no sting; but that of the male is frequently furnished

* See Chap XI. concerning the Transformation of Animals.

with a kind of forceps or pincers. To this order belongs the *libella*, or *dragon-fly*, an insect of very splendid and variegated colours. It is a large and well known fly, and frequents rivers, lakes, pools, and stagnating waters, in which the females deposit their eggs. Their mode of generating is singular. Different species of them appear from the beginning of summer to the middle of autumn. They generally fly in pairs, and in a straight line, the male pursuing the female. The organs of the male are situated in his breast: When he overtakes her, with the forceps in his tail he lays hold of her by the neck, while she, by an instinctive impulse, makes the lower end of her body approach the male organs. In this united situation they form a kind of ring, have the appearance of a double animal, and fly along till the purpose is accomplished. Under the same order is comprehended the *phryganea*, or *spring-fly*: The larvae or caterpillars of this genus live in the water, and are covered with a silken tube. They have a very singular aspect; for, by means of a gluten, they attach to the tubes in which they are inclosed small pieces of wood, sand, gravel, leaves of plants, and not unfrequently live testaceous animals, all of which they

drag along with them. They are very commonly found in salads of the water-cress; and, as they are often entirely covered with green leaves, they have the appearance of animated plants. They are in great request among fishermen, by whom they are distinguished by the name of *stone*, or *cod-bait*. The fly, or perfect insect, frequents running waters, in which the females deposit their eggs.

The *fifth* order is termed *hymenoptera*. In general, the insects belonging to this order have four membranaceous and naked wings. In some of the genera, however, the neuters, and, in others, the males, or even the females, have no wings. Their tails, except in the male sex, are armed with a sting.—The female of the *cynips*, an insect belonging to this order, inserts her eggs into the leaves of the oak, and the caterpillars produced from them give rise to the galls employed in the composition of ink.—This order likewise includes the wasp, the bee, and the ant. Many of the wasp kind, like the bees, live in society, make combs in which the females deposit their eggs, and feed their caterpillars with an inferior species of honey. Others of them construct a separate nest for each individual egg.—The bee is an insect too well known to require

quire a particular description. The males have no sting; but the females, and the drones, or neuters, have a very sharp pointed sting concealed in their abdomen. The female of the honey bee is much larger than the male, or the neuter. Her feelers contain fifteen articulations. Her abdomen is composed of seven segments, and is much longer than her wings. The feelers of the male contain only eleven articulations. The neuters are much smaller than the males or females, and their feelers consist of fifteen articulations.—The sting, with which the male and female *ants* are armed, is concealed within the abdomen. The males and females of the ant are furnished with wings, but the neuters are deprived of these instruments of motion. The ants live in societies which are composed of males, females, and neuters. The males are much smaller than the females and neuters. Soon after the males and females propagate the species, they all die. Some of the neuters, however, survive the winter; but they remain in their habitation without movement, or discovering any signs of life. From these circumstances in the history of ants, it is apparent, that the industry and sagacity so long and so universally ascribed to these little animals

animals could be of no use either to themselves or to their progeny. The female, after depositing her eggs, takes no farther care of her offspring. But, what is singular, the important office of feeding the *larvae*, or caterpillars, after the eggs are hatched, is left entirely to the neuters. This affectionate and assiduous attention of the neuters to a progeny neither begot nor brought forth by them, is so astonishing, so contrary to the general oeconomy of Nature, that no reasoning or theory can account for a fact so uncommon, till farther discoveries shall be made in the history of these surprising animals. What is still more singular, after the caterpillars are transformed into the chrysalis state, the neuters are incessantly and anxiously employed in preserving the chrysales from humidity when the weather is wet, and in exposing them to the warmth of the sun when it is fair. These chrysales are larger than the animals themselves, and yet they carry them off with ease and rapidity.

The *sixth* order of insects is termed *diptera*, or two-winged insects. The different species of this order, beside wings, are furnished with what is called a *halter*, or a *poiser*, which is situated under each wing, and is terminated by a *capitulum*, or knob. This order comprehends

hends ten genera and a multitude of species. The caterpillars of the *oestrus*, or *gad-fly*, lie concealed in the skins of cattle, where they are nourished during the whole winter. The perfect insects are frequent wherever horses, cows, or sheep, are grazing. Some of them deposit their eggs in the skins of cows or oxen; others deposit them in the intestines of horses, to which they get access by the anus; and others in the nostrils of sheep. In these habitations, the caterpillars reside till they are full grown, when they throw themselves down to the earth, and generally pass the chrysalis state under the first stone they meet with.—The *musca*, or common *fly*: The mouth of this insect consists of a soft, fleshy proboscis, with two lateral lips. The caterpillars of some of this genus devour the pucerons; others consume all kinds of putrid flesh; others are found in cheese; others in the excrements of different animals; and many of them live in the water, and prefer that which is most corrupted and muddy.—The mouth of the *culex*, or *gnat*, consists of a flexible sheath, inclosing four bristles, or pointed stings. The feelers of the female gnat are plain like a thread; but those of the male are beautifully feathered. The worms or caterpillars of this genus are
com-

commonly found in stagnant waters. The gnats generally frequent woods and marshy places. The females, in particular, are very troublesome, and sting severely.—The feet of the *hippobosca*, or *horse-fly*, are armed with a number of nails or crotchets. In some species, the wings cross each other; in others, they are open. The horse-flies frequent woods and marshy grounds, and are extremely incommodious to birds and quadrupeds, whose blood is the only food of these insects.

The *seventh* order of insects Linnaeus denominates *aptera*, because neither males nor females are furnished with wings. This order comprehends thirteen genera, and a great number of species, many of which are very offensive and noxious to the human species. The *pediculus*, or *louse*, has six legs, two prominent eyes, and its mouth contains a sting or sucker, by which it extracts blood and other juices from the bodies of animals. Though almost every different animal is infested with a peculiar species of lice, the specific characters of very few of them have hitherto been ascertained. Lice are of various forms. Some of them are oval, others oblong, and others long and slender. They are oviparous animals, and their legs
are

are large in proportion to the size of their bodies. Before they arrive at maturity, they change their skin several times. They are supposed to be hermaphrodites. This circumstance, if true, may partly account for their prodigious multiplication. Swammerdam, who dissected a great number, assures us, that he never found one without an ovary, nor ever discovered the organs peculiar to the male sex. If this structure be universal, the louse is an hermaphrodite of a very peculiar kind; because it must be capable of foecundating itself. Several species of worms are hermaphrodites; but, instead of foecundating themselves, they are obliged to impregnate each other.—The *pulex*, or *flea*, has likewise six legs, the articulations of which are so exceedingly elastic, that the animal is enabled by their means, to spring to a surprising distance. It has two fine eyes, and its body is covered with crustaceous scales. The flea is the only insect belonging to this order which undergoes a transformation similar to that of the former orders: All the other wingless insects are produced in a perfect state either by the mother, or from eggs. The caterpillars of the flea have forked tails, and are very small and lively. They may be
nourish-

nourished in boxes, and fed with flies, which they greedily devour. Before changing into the chrysalis state, they live fourteen or fifteen days in the form of caterpillars.—*Aranea*, or spider: This genus comprehends a great many species. The spider has eight feet, and an equal number of immoveable eyes. The chief prey of the spider is flies, animals whose motions are extremely quick and desultory. To enable the spider to observe their movements in every direction, she is furnished with eight eyes, the position of which merits attention: Two of them are placed on the top of the head, other two on the front, and two on each side. The mouth is armed with two crotchets, by which it seizes and kills its prey. Round the anus there are several muscular instruments, shaped like nipples or teats. Each of these contain about a thousand tubes or outlets for threads so extremely minute, that many hundreds of them must be united before they form one of those visible ropes of which the spider's web is composed. The figure of the web varies according to the species, or the situation the animal chooses for its abode. After the web is completed, some species reside in the center, and others occupy the extremity of their habitations, where they

they lie in ambush, with astonishing patience, till an ill-fated fly is accidentally entangled. The spider, from the vibration of the threads, perceives his prey, rushes forth from his cell, instantly seizes it with his fangs, devours its vitals, and afterwards rejects the exhausted carcase. Spiders prey upon all weaker insects, and even upon their own species.—The *scorpion*: This venomous insect is a native of warmer climates than those of the north of Europe. It has eight feet, and two claws, the last of which are situated on the fore part of the head. Like the spider, the scorpion has eight eyes, three of which are placed on each side of the breast, and the other two on the back. The tail is long, jointed, and terminates in a sharp crooked sting. The venom of the scorpion is more destructive than that of any other insect; and is sometimes fatal in Africa and other hot regions.

The *last* division of insects is termed *vermes*, or *worms*, by Linnaeus. This class comprehends not only all the insects commonly called *worms*, but all the testaceous animals, and the zoophites, or plant-animals. The structure of several genera belonging to this class is extremely singular. After giving a few exam-

examples, we shall hasten to the conclusion of the present subject.

The body of the *gordius*, or *hair-worm*, is long, shaped like a thread or hair, smooth, and round. A species of the hair-worm is very common in our fresh waters, and is perfectly harmless. In Scotland, it is a vulgar and foolish notion, that the hair of a horse's tail, when thrown into the water, is converted into this worm. Though inoffensive in this country, the hair-worm of Africa, and of both the Indies, is extremely noxious. It is of a pale yellowish colour, and is frequently met with among the grass, especially when covered with dew. It often insinuates itself into the naked feet or limbs of children and unwary persons, where it produces an inflammation, which is sometimes fatal. It may be extracted by tying a thread round its head, and then pulling it gently out of its abode. But this operation requires great caution; for, if the animal is broken, the part which remains does not die, but, in a short time, regains what it had lost, and becomes equally entire and troublesome as if it had received no injury — The *lumbricus*, or *earth worm*: The body of this worm is cylindrical, consists of many rings, and the middle is encompassed

fed with an elevated belt. It is likewise furnished with sharp prickles, which the animal can erect or depress at pleasure. Through certain perforations in the skin, it occasionally emits a slimy fluid, which lubricates its body, and facilitates its passage into the soil. The intestines of this worm are always filled with a fine earth, which seems to constitute its only nourishment. Earth-worms, like snails, are hermaphrodite. The parts of generation are placed near the neck, and they mutually impregnate each other. This operation is performed on the surface of the ground; and, while thus employed, they will allow themselves to be crushed to pieces rather than part. The females deposit their eggs in the earth, where they are hatched. These worms, like the polypus, when cut through the middle, reproduce, and each portion becomes a distinct individual. According to the different periods of their growth, their colour varies; but, in general, it is a dusky red.

The *sepia*, or *cuttle-fish*, though comparatively a large animal, some of them being two feet long, is ranked by Linnaeus under the class of *worms*. The structure of the cuttle fish is remarkable. Its body is cylindrical,

cal, and, in some of the species, is entirely covered with a fleshy sheath; in others, the sheath reaches only to the middle of the body. The sepia has eight tentacula, or arms, beside two feelers, as they are called, which are much longer than the arms. Both the feelers and arms are furnished with strong cups, or suckers, shaped like the cup of an acorn, by means of which the animal seizes his prey, and firmly attaches itself to rocks, or to the bottom of the sea. It has two large and prominent eyes. What is still more singular, it is furnished with a hard, strong, horny beak, precisely similar, both in texture and substance, to the bill of a parrot. With this bill, the cuttle-fish is enabled to break the shells of limpets, and other shell-animals, upon which it chiefly feeds. In the belly, there is an aperture through which the animal, when pursued by its enemies, emits a fluid as black as ink, tinges the water, and often escapes by this ingenious stratagem. The ancient Romans frequently used this black fluid as ink in writing. The males and females copulate by a mutual embrace. The female deposits her eggs upon sea-plants in parcels resembling bunches of grapes. At the instant they drop from the mother, the
eggs

eggs are white; but the male immediately coats them over with a black liquor. The male perpetually accompanies the female. When the female is attacked, he braves every danger, and often rescues her at the hazard of his own life. The bone of the cuttle-fish is very light, and, when pulverized, it is employed by different artists in making moulds.

The *medusa* is an animal which has the appearance of a lifeless mass of jelly floating on the surface of the ocean. Its body is roundish, flattened underneath, and the mouth is situated in the center of the under part. There are many species of this seemingly most imperfect, defenceless, and abject part of animated nature. They are, however, furnished with tentacula, by which they seize insects and the small fry of fishes, convey them to their mouths, and devour them. Although the sport of the waves, and the prey of every fish that approaches them, they are gregarious animals, and, particularly in warm climates, sometimes collect in such numbers as to have the appearance of whitish rocks under the surface of the ocean.

We have thus given a short sketch of the structure of animals, from man down to the insect tribes, and shall now conclude with a few remarks.

In all the variety of animated beings whose general structure has been exhibited, the intelligent reader will easily perceive, that the bodily forms of the different kinds are exactly adapted to the rank they hold in the creation, and that their oeconomy and manners are strictly and invariably connected with their structure and organs. If a new animal appears, and if its figure be uncommon, it may with safety be pronounced, that its manners are equally uncommon. Change the external or internal form of an animal; diminish the number of stomachs in the ruminating tribes; or give to the horse a parrot's bill; and the species will be annihilated.

The comparative power, or strength, of animals depends not on structure alone. Mental faculties, and docility, or the capacity of receiving instruction, seem to be the greatest sources of animal power. Hence man's unlimited empire over all other creatures. The inventions of language, of arms, of writing, printing, and engraving, have been the chief means of extending his influ-

influence, and of his acquiring the dominion of the earth. By these arts, men transmit the improvements, the inventions, and the acquisitions, of one age to another. By these arts, the dispositions of men are softened, their manners become more and more civilized, humanity is gradually extended and refined, and the grosser animosities yield to external politeness and decorum at least, if the feelings themselves be not blunted. How far this progress of science, and the peaceful arts of life, by the accumulation of ages, may proceed, it is impossible to determine. But the time, it is to be hoped, is not very remote, when the fiercer contentions of nations will cease, when selfishness and venality, which at present seem to be inseparable from commercial states, will give way to generosity of temper, and uprightness of conduct.

C H A P T E R III.

Of the Respiration of Animals—Air necessary to the existence of all animated beings—The various modifications of the organs employed by Nature for the transmission of Air into animal bodies.

IT is foreign to the design of this chapter to mention the different kinds of air; to unfold its composition; or to recapitulate the innumerable benefits derived from it in the animal and vegetable kingdoms, in the arts of life, and in the texture and cohesion of inanimate bodies. For our purpose, it is sufficient to observe, that by *air* is meant that common elastic fluid which pervades this globe, and which by its weight, its pressure in all directions, and its compressibility, insinuates itself into every vacuity, and is necessary to the existence of every animal and vegetable being.

In man, and the larger land animals, air is taken into the body by the lungs. When an animal inspires, the external air passes through the apertures of the mouth and nose into the trachea

trachea or wind-pipe, and thence directly into the lungs. This air, by insinuating itself into the numerous cells of the lungs, necessarily inflates them, and, when retained for a second or two, produces an uneasy sensation. To remove this disagreeable feeling, the animal instinctively, by the exertion of particular muscles destined by Nature for that purpose, forces out the air, and thus removes the offending cause. The lungs, after the air is thrown out, instead of being inflated, collapse; and, if a fresh supply is not soon taken in, a similar uneasy sensation is felt, which obliges the animal again to inspire. This alternate reception and rejection of air goes on during the life of the animal, and is distinguished by the general name of *respiration*. But, when treating more accurately of the subject, the act of taking air into the lungs is called *inspiration*, and the act of throwing it out is termed *expiration*.

That the respiration of air is indispensable to the existence of land-animals, has been proved by innumerable experiments made with the air-pump. Mice, rats, rabbits, cats, dogs, &c. when placed in an exhausted receiver, instantly become restless, and discover symptoms of pain. Their bodies swell, and

their life is soon extinguished. Indeed, our own feelings are sufficient to ascertain this fact. No person can remain long either in a state of inspiration or expiration without being suffocated.

But the alternate motions of inspiration and expiration, joined to the circulation of the blood through the lungs, may be considered as the more mechanical effects of respiration. Though these operations are absolutely necessary to the existence of animals, yet the air itself has been supposed to impart some vital principle to the blood, without which life could not be continued.

The ingenious Doctor Crawford, in his treatise on Animal Heat, has rendered it probable, that the respiration of air is the cause of that vital warmth without which no animal can exist. After mentioning a well known fact, that all bodies, whether animate or inanimate, contain a certain quantity of fire as a principle in their composition, the Doctor remarks, that this quantity, in different bodies, varies according to their nature or texture; that this fire, when in a latent or quiescent state, is termed *absolute heat*; that, when substances of different textures have a given quantity of heat thrown into them,
their

their temperature will be discovered to be different by the thermometer ; for the same quantity of heat which raises one body to a certain degree, will raise another to a greater or a less ; and this different disposition of bodies is called their capacity of containing absolute heat.

Doctor Crawford next endeavours to prove by experiments, that, when phlogiston is added to any body, its capacity of containing absolute heat is diminished ; and that, when phlogiston is abstracted from the same body, its capacity of receiving absolute heat is augmented. Hence he infers, that heat and phlogiston seem to constitute two opposite principles in nature. By the action of heat upon bodies, the force of their attraction to phlogiston is diminished ; and, by the action of phlogiston, a part of the absolute heat, which exists in every substance as an element, is expelled. ‘ Hence,’ says the Doctor, ‘ animal heat seems to depend upon a process similar to a chemical elective attraction. The air is received into the lungs, containing a great quantity of absolute heat. The blood is returned from the extremities, highly impregnated with phlogiston. The attraction of the air to the phlogiston is
‘ greater

‘ greater than that of the blood. This principle will therefore leave the blood to combine with the air. By the addition of the phlogiston, the air is obliged to deposit a part of its absolute heat; and, as the capacity of the blood is, at the same moment, increased by the separation of the phlogiston, it will instantly unite with that portion of heat which had been detached from the air.

‘ We learn from Doctor Priestley’s experiments with respect to respiration, that arterial blood has a strong attraction to phlogiston: It will, consequently, during the circulation, imbibe this principle from those parts which retain it with the least force, or from the putrescent parts of the system: And hence the venous blood, when it returns to the lungs, is found to be highly impregnated with phlogiston. By this impregnation, its capacity for containing heat is diminished. In proportion, therefore, as the blood, which had been dephlogisticated by the process of respiration, becomes again combined with phlogiston, in the course of the circulation, it will gradually give out that heat which it had
‘ received

‘ received in the lungs, and diffuse it over
 ‘ the whole system *.’

The Doctor afterwards proceeds to assign a reason why the heat of animals is always equal. ‘ As animals,’ says he, ‘ are continually absorbing heat from the air, if there were not a quantity of heat carried off, equal to that which is absorbed, there would be an accumulation of it in the animal body. The evaporation from the surface, and the cooling power of the air, are the great causes which prevent this accumulation. And these are alternately increased and diminished, in such a manner as to produce an equal effect. When the cooling power of the air is diminished by the summer heats, the evaporation from the surface is increased; and when, on the contrary, the cooling power of the air is increased by the winter colds, the evaporation from the surface is proportionally diminished †.’

This theory, though not supported by mathematical evidence, is not only ingenious, but seems to make a nearer approach to

* Crawford on Animal Heat; pag. 73.

† Ibid. pag. 84.

truth than any that has hitherto been invented †.

Respiration, beside being the probable cause of the equable continuation of heat in animals, produces many other salutary and useful effects in the oeconomy of animated bodies. There is a most intimate connection between the act of respiring and the circulation of the blood. When respiration is, for a short time, interrupted by the fumes of burning sulphur, by mephitic air, or by remaining some minutes under water, the action of the heart ceases. But, in many cases of this kind, the motion of the heart may, and frequently has been renewed, by blowing air into the lungs, and by the application of stimulating substances to different organs of the body. In persons seemingly dead from a temporary suspension of respiration, if the lungs can be excited to act, the motion of the heart instantly commences,

‡ If the reader is desirous of seeing some pertinent remarks on Doctor Crawford's Theory of Animal Heat, he may consult Doctor Gardiner's *Observations on the Animal Oeconomy, and on the causes and cure of diseases*, an ingenious and useful performance, lately published, and which merits much more attention from Philosophers and Physicians than it has hitherto received.

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the circulation of the blood is restored, and life is recovered. This intimate connection between respiration and the action of the heart, is one of those astonishing facts in the animal oeconomy, the causes of which will perhaps forever elude the keenest researches of the human intellect. All we know is, that certain functions are indispensable to the existence of animals, and that, if any of them are suspended for a few seconds, life is extinguished; namely, the action of the brain and nerves, the circulation of the blood, respiration, and a probable result of respiration, animal heat. These functions, from their importance in the system, have received the appellation of *vital functions*. There are other functions of the body, called *natural*, which are no less necessary to life, as the digestion and concoction of aliment, the various secretions and excretions. But they are distinguished from the vital functions, because some of them may be suspended for a considerable time without materially injuring the body.

Respiration commences instantly after birth, and is instinctively continued during life. In the foetus state, as formerly mentioned

tioned *, respiration is unnecessary, because the circulation of the general mass of blood is carried on through a different channel. In the act of inspiration, we are conscious of making a certain effort ; but in the act of expiration we scarcely perceive any exertion whatever.

Beside the circulation of the blood, and the continuation of the vital warmth, respiration gives rise to many other important functions in the animal oeconomy. All animals who respire, beside a watery vapor, exhale great quantities of mephitic or corrupted effluvia, which, if retained in the lungs, or breathed by other animals, would soon prove fatal. The muscles of respiration, of which we have the command, are employed in many other operations of the body, beside the mere act of breathing air. All animals furnished with lungs express their wants, their affections and aversions, their pleasures and pains, either by words, or by sounds peculiar to each species. These different sounds are produced by straitening or widening the glottis and wind-pipe, or, in general, the passage through which the air passes in respiration. The inferior animals

* See above, page 103.

are by this means enabled to express themselves, though not by articulate sounds, in such a manner as to be perfectly intelligible to every individual of a species. On man alone, Nature has bestowed the faculty of speaking, or of expressing his various feelings and ideas, by a regular, extensive, and established combination of articulate sounds. To have extended this faculty to the brute creation, would not, it is probable, have been of any use to them; for, though some animals can be taught to articulate, yet from a defect in their intellect, none of them seem to have any idea of the proper meaning of the words they utter. Speech is performed by a very various and complicated machinery. In speaking, the tongue, the lips, the jaws, the whole palate, the nose, the throat, together with the muscles, bones, &c. of which these organs are composed, are all employed. This combination of organs we are taught to use when so young that we are hardly conscious of the laborious task, and far less of the manner by which we pronounce different letters and words. The mode of pronouncing letters and words, however, may be learned by attentively observing the different organs employed, by the speaker. By this means we
are

are enabled to correct various defects of speech, and even to teach the dumb to speak; for dumbness is seldom the effect of imperfection in the organs of speech, but generally arises from a want of hearing; and it is impossible for deaf men to imitate sounds which they never heard, except they be taught to use their organs by vision and by touching.

When about to laugh, we make a very full inspiration, which is succeeded by frequent, interrupted, and sonorous expirations. When the titillation is great, whether it arises from the mind or body, these convulsive expirations sometimes interrupt the breathing to such a degree as to endanger suffocation. Moderate laughing, on the contrary, promotes health: By agitating the whole body, it quickens the circulation of the blood, gives an inexpressible cheerfulness to the countenance, and banishes every kind of anxiety from the mind.

In weeping, we employ nearly the same organs as in laughing. It commences with a deep inspiration, which is succeeded by short, broken, sonorous, and disagreeable expirations. The countenance has a dismal aspect, and tears are poured out. Weeping originates from grief, or other painful sensations

fations either of body or mind : When full vent is given to tears, grief is greatly alleviated. Both laughing and weeping have been reckoned peculiar to man. But this notion seems not to be well founded. Though the other animals express not their pleasures or pains in the same manner as we do, yet all of them exhibit their pleasant or painful feelings by symptoms or cries, which are perfectly understood by the individuals of each species, and, in many instances, by man. A dog, when hurt, complains in the bitterest terms; and, when he is afraid, or perhaps melancholy, he expresses the situation of his mind by the most deplorable howlings. A bird, when sick, ceases to sing, droops the wing, abstains from food, assumes a lurid aspect, utters melancholy, weak cries, and exhibits every mark of depressed spirits. By this means, animals intimate the assistance they require, or soften those who maltreat them. Their plaintive cries are sometimes so affecting as to disarm their enemies, or procure the aid of their equals. On the other hand, when animals are pleased or caressed, they discover, by their countenance, by their voice, by their movements, unequivocal symptoms of cheerfulness and
alacrity

alacrity of mind. Thus the expressions of pleasure and pain by brute animals, though not uttered in the precise manner with those of the human species, are perfectly analogous, and answer the same intentions of Nature.

By respiration, and the instruments employed in the performance of it, the larger animals are not only brought forth, but are enabled to extract milk from the breasts of the mother. By respiration, odors are conveyed to the nose; coughing, sneezing, yawning, sighing, singing, vomiting, and many other functions in the animal economy, are at least partly accomplished.

After this general view of the respiration of man and of quadrupeds, we proceed, according to the method laid down, to give some account of the same function in the other classes of animals.

With regard to BIRDS, though, like other land-animals, they respire by means of lungs, Nature has enabled them to transmit air to almost every part of their bodies. The lungs of birds are so firmly attached to the diaphragm, the ribs, the sides, and the vertebrae, that they can admit of very little dilatation or contraction. Instead of being impervious, the substance

stance of the lungs, as well as of the diaphragm, to which they adhere, is perforated with many holes or passages for the transmission of air to the other parts of the body*. To each of these perforations a distinct membranous bag is joined. These bags are extremely thin and transparent. They extend through the whole of the abdomen, are attached to the back and sides of that cavity, and each of them receives air from their respective openings into the lungs. The cells in birds which receive air from the lungs are found not only in the soft parts, but in the bones. That ingenious and accurate anatomist, Mr. John Hunter of London, remarks, that the bones of birds which receive air are of two kinds: ‘Some, as the sternum, ribs, ‘and vertebrae, have their internal substance ‘divided into innumerable cells, whilst others, ‘as the os humeri and the os femoris, are ‘hollowed out into one large canal, with ‘sometimes a few bony columns running ‘across at the extremities. Bones of this ‘kind may be distinguished from those that ‘do not receive air by certain marks: I. By

* This fact seems to have been first mentioned by the celebrated Doctor Harvey. See Harvey de Generat. Animal. Exercit. 3.

‘ their

‘ their less specific gravity: 2. By being less
‘ vascular, and therefore whiter: 3. By their
‘ containing little or no oil, and consequently
‘ being more easily cleaned; and, when clean-
‘ ed, appearing much whiter than common
‘ bones: 4. By having no marrow, or even
‘ any bloody pulpy substance in their cells:
‘ 5. By not being, in general, so hard and firm
‘ as other bones; and, 6. By the passage that
‘ allows the air to enter the bones, which can
‘ easily be perceived. In the recent bone we
‘ may readily discover holes, or openings, not
‘ filled with any such soft substance as blood-
‘ vessels or nerves; and it happens that seve-
‘ ral of these holes are placed together, near
‘ that end of the bone which is next to the
‘ trunk of the bird; and are distinguished by
‘ having their external edges rounded off;
‘ which is not the case with the holes through
‘ which either nerves or blood-vessels pass
‘ into the substance of the bone*.’

Mr. Hunter afterwards informs us, that the lungs, at the anterior part, open into a number of membranous cells, which lie upon the sides of the pericardium, and communicate with those of the sternum. At the su-

* Hunter's Observations on certain parts of the Animal Oeconomy, pag. 79.

perior part, the lungs open into the large cells of a loose net-work, through which the wind-pipe, gullet, and large vessels, pass as they proceed to and from the heart. These cells, when distended with air, augment considerably the part where they are situated; and this augmentation, or swelling, is generally a mark either of anger or of love. This tumefaction is remarkable in the turkey-cock, in the pouting pigeon, and in the breast of a goose when she cackles. These cells communicate with others in the axilla, under the large pectoral muscle. In most birds, the axillary cells communicate with the cavity of the os humeri by small openings in the hollow surface near the head of that bone. In some birds, these cells are continued down the wing, and communicate with the ulna and radius; in others, they extend even to the pinions. The posterior edges of the lungs open into the cells of the vertebrae, into those of the ribs, the canal of the spinal marrow, the sacrum, and other bones of the pelvis; from these parts the air finds a passage into the thigh-bone. ‘Thus,’ continues our learned and indefatigable author, ‘the cells of the abdomen, those surrounding the pericardium, those situated at the lower and fore-

‘ part of the neck, and in the axilla, those in
‘ the cellular membrane under the pectoral
‘ muscles, as well as in that which unites the
‘ skin to the body, all communicate with the
‘ lungs, and are capable of being filled with
‘ air; and again from these the cells of the
‘ sternum, ribs, vertebrae of the back and
‘ loins, bones of the pelvis, the humeri, the
‘ ulna and radius, with the pinions and thigh-
‘ bones, can in many birds be furnished with
‘ air*.’

These facts, which our author candidly acknowledges had been formerly observed, led him, in the year 1758, to make experiments on the breathing of birds, in order to prove the free communication between the lungs and the several parts of the body mentioned above.

‘ First,’ says he, ‘ I made an opening into
‘ the belly of a cock, and having introduced
‘ a silver canula, tied up the trachea; I found
‘ that the animal breathed by this opening,
‘ and might have lived; but, by an inflammation in the bowels coming on, adhesions were produced, and the communication cut off.

* Hunter’s Observations on certain parts of the Animal Oeconomy, pag. 82.

‘ I next

‘I next cut the wing through the os humeri, in another fowl, and tying up the trachea, as in the cock, found that the air passed to and from the lungs by the canal in this bone. The same experiment was made with the os femoris of a young hawk, and was attended with nearly the like success †.’

The extreme singularity of this almost universal diffusion of air through the bodies of birds, naturally excited a desire to discover what might be the intention of Nature in producing a structure so extraordinary. Mr. Hunter first imagined that it might be intended to assist the act of flying, by increasing the volume and strength of the animal, without adding to its weight, which must be diminished; because the specific gravity of the external air is superior to that of the internal air, which is rendered more rare by the heat of the animal's body. This opinion was corroborated, by considering that the feathers of birds, and particularly those of the wings, contain a great quantity of air. With his usual ingenuousness, however, Mr. Hunter, in opposition to his first conjecture,

† Hunter's Observations on certain parts of the Animal Oeconomy, pag. 82.

informs us, that the ostrich, which does not fly, was amply provided with air-cells dispersed through its body; that the wood-cock, and some other flying birds, were not so liberally supplied with these cells as the ostrich; and that the bat had no such peculiarity of structure. With regard to the ostrich, though it is not intended to fly, it runs with amazing rapidity, and, consequently, requires similar resources of air.

He next conjectured from analogy, that the air-cells in birds ought to be considered as an appendage to the lungs; because in the snake, viper, and several other amphibious animals, the lungs are continued, in the form of two bags, through the whole abdomen, the upper part of which can only perform the office of respiration with any degree of effect; because the lower part has comparatively few air-vessels. ‘The air,’ says Mr. Hunter, ‘must pass through this upper part before it gets to the lower in inspiration, and must also repass in expiration; so that the respiratory surface has more air applied to it than what the lungs of themselves could contain. There is, in fact, a great similarity between birds and that class of animals called *amphibious*; and, although a
bird

‘ bird and a snake are not the same in the
‘ construction of the respiratory organs, yet
‘ the circumstance of the air passing in both
‘ beyond the lungs, into the cavity of the ab-
‘ domen, naturally leads us to suppose, that
‘ a structure so similar is designed in each to
‘ answer a similar purpose. This analogy is
‘ still farther supported by the lungs in both
‘ consisting of large cells. Now, in amphi-
‘ bious animals, the use of such a conforma-
‘ tion of lungs is evident; for it is in conse-
‘ quence of this structure that they require to
‘ breathe less frequently than others. Even
‘ considering the matter in this light, it may
‘ still, in birds, have some connection with
‘ flying, as that motion may easily be ima-
‘ gined to render frequency of respiration in-
‘ convenient, and a reservoir of air may there-
‘ fore become singularly useful. Although
‘ we are not to consider this structure in birds
‘ to be an extension of lungs, yet I can easily
‘ conceive this accumulation of air to be of
‘ great use in respiration; for, as we observ-
‘ ed in the viper, that the air, in its passage
‘ to and from these cells, must certainly have
‘ a considerable effect upon the blood in the
‘ lungs, by allowing a much greater quantity
‘ of air to pass in a given time, than if there
‘ was

‘ was no such construction of parts. And this
‘ opinion will not appear to be ill founded, if
‘ we consider, that, both in the bird and the
‘ viper, the surface of the lungs is small in
‘ comparison to what it is in many other ani-
‘ mals which have not this extension of cavi-
‘ ty.—We must not, however, give up the idea
‘ of such structure being of use in flying; for
‘ I believe we may set it down as a general
‘ rule, that, in the birds of longest and highest
‘ flight, as eagles, this extension, or diffusion
‘ of air, is carried farther than in the others;
‘ and this opinion is strengthened, by com-
‘ paring this structure with the respiratory
‘ organs in the flying insects, which are com-
‘ posed of cells diffused through the whole
‘ body; and these are extended even into the
‘ head and down the extremities, while there
‘ is no such structure in those that do not
‘ fly, as the spider,’ &c.

Though Mr. Hunter’s modesty has not permitted him to draw his conclusion in a positive manner, he seems to have proved decidedly, that one use of the general diffusion of air through the bodies of birds is to prevent their respiration from being stopped or interrupted by the rapidity of their motion through a resisting medium. The re-
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sistance of the air increases in proportion to the celerity of the motion. Were it possible for man to move with a swiftness equal to that of a swallow, the resistance of the air, as he is not provided with internal reservoirs similar to those of birds, would soon suffocate him. Neither does the difficulty he mentions, with regard to the structure of the ostrich, seem to contradict his theory; for though, as formerly remarked, the ostrich does not fly, he runs with astonishing rapidity.

The respiration of air is not only necessary to the existence of land-animals, but to that of FISHES of every denomination. Coetaneous fishes, or those of the whale kind, respire, like man and quadrupeds, by means of lungs; and, of course, they are obliged, at certain intervals, to come to the surface, in order to throw out the former air, and to take in a fresh supply.

Instead of lungs, the other species of fishes are furnished with gills, through which they respire both water and air; for air is universally diffused or mixed with every portion of water. When a free communication with the external air is prevented by ice, or by artifice, fishes immediately discover symptoms

toms of uneasiness, and soon perish. Ælian informs us, that, in winter, when the river Ister was frozen, the fishers dug holes in the ice; that great numbers of fishes resorted to these holes; and that their eagerness was so great, that they allowed themselves to be seized by the hands of the fishermen. Rondeletius made many experiments on this subject. If, says he, fishes are put into a narrow-mouthed vessel filled with water, and a communication with the air be preserved, the animals live, and swim about, not for days and months only, but for several years. If the mouth of the vessel, however, be so closely shut, either with the hand, or any other covering, that the passage of the air is excluded, the fishes suddenly die. Immediately after the mouth of the vessel is closed, the creatures rush tumultuously, one above another, to the top, contending which of them shall soonest receive the benefit of the air*. In the shallow parts of rivers, when frozen, many fishes are found dead. But, when parts of a river are deep or rapid, the fishes fly from the ice, and by this means avoid destruction.

* Rondeletius, lib. 4. cap. 9.

These, and similar experiments, have been repeated by Mr. Willoughby, and many other modern authors; and they have uniformly been attended with the same event. A carp, in a large vessel full of water, was placed in the receiver of an air-pump. In proportion as the air was exhausted by working the pump, the surface of the animal's body was covered with a number of bubbles. The carp soon breathed quicker, and with more difficulty: A little after, it rose to the surface in quest of air. The bubbles on its surface next disappeared; the belly, which before was greatly swollen, suddenly collapsed; and the animal sunk to the bottom, and expired in convulsions.

Thus the respiration of air is as necessary to the existence of fishes as to that of land-animals; for none of them can live long when deprived of this vivifying element. Fishes, indeed, seem to require a smaller quantity of air than animals who have a constant and free communication with the atmosphere. The bodies and fluids of fishes are colder than those of land-animals; and, of course, if Doctor Crawford's theory be well founded, fishes require less air to support

port the proportionally small quantity of heat they possess.

An analogy between fishes and birds deserves here to be noticed. Both of these classes of animals are rapid in their motions; and both of them, beside respiring by lungs or gills, have receptacles of air within their bodies. Fishes transmit small quantities of air through their gills; but Nature has provided most of them with air-bags or bladders, which may answer the double purpose of enabling them to ascend and descend in the water, and to communicate a vital principle to their whole system.

We shall conclude this subject with an account of the modes employed by Nature for transmitting air into the bodies of INSECTS.

In this seemingly contemptible, and often noxious class of animals, Nature has exhibited a wonderful diversity of form, of manners, of instincts, of deformity, and of beauty. But, however insignificant these creatures may appear to inattentive observers, Nature has been equally provident in the formation of their bodies, and in the means of preserving the different individuals, according to their kinds, as in the larger animals, which have the appearance of more importance

tance in the scale of being. To insects she has denied lungs similar to those of men, quadrupeds, birds, and fishes; but, as the transmission of air into their bodies was necessary to continue the principle of life, she has furnished them with peculiar instruments and apparatus for accomplishing this indispensable purpose.

Air is conveyed into the bodies of insects by instruments called *tracheae* or *stigmata*. The *tracheae*, or wind-pipes, are, in many insects, long tubes protruding externally from different parts of the body. In some, they proceed from the posterior part, and have the appearance of one, two, or three tails; in others, they arise from the back or sides. The *stigmata* are small holes, generally of a different colour from the rest of the body, and run along the sides of many caterpillars in regular and beautifully dotted lines. That these *tracheae* and *stigmata* are destined for the transmission of air, has been proved by repeated experiments; for, when stopped up by the application of oil, or other unctuous substances, the animals soon lose their existence.

In contemplating the parts of animals, when the uses of these parts are not apparent,
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we are apt to deceive ourselves by rashly supposing them to answer purposes for which they were never intended by Nature. Impressed with this idea, M. de Reaumur was not satisfied with the notion of Goedart and others, that the long tails of certain worms were intended to keep them steady in their motions, and to prevent them from rolling. Reaumur observed, that these worms or grubs could lengthen or shorten their tails at pleasure, but that they were always longer than the animal's body. Because these tails have some resemblance to that of a rat, he distinguishes the animals by the name of *rat-tailed worms*. These worms are aquatic, and never appear on dry ground till they are about to undergo their first transformation. Reaumur, in order to observe their oeconomy more closely, collected a number of rat-tailed worms, and put them into a glass vessel filled two inches high with water. At first they were considerably agitated, each seemingly searching for a proper place of repose. Some of them swam across, others attached themselves to the sides, and others rested at the bottom of the vessel. In a quarter of an hour they were almost entirely tranquil, and Reaumur soon discovered the real use of their long tails.

tails. Upon examining the vessel, he found that each of the animals, in whatever situation they were placed, extended its tail exactly to the surface; that, like other aquatic insects, the respiration of air was necessary to their existence; and that the tail, which is tubular, and open at the extremity, was the organ by which this operation was performed. In this experiment, the distance from the bottom to the surface was two inches, and, of course, the tails were of an equal length. To discover how far the animals could extend their tails, this most ingenious and indefatigable philosopher gradually augmented the height of the water, and the tails uniformly rose to the surface till it was between five and six inches high. When the water was raised higher, the animals immediately quitted their station at the bottom, and either mounted higher in the water, or fixed upon the sides of the vessel, in situations which rendered it convenient for them to reach the surface with the points of their tails. These tails consist of two tubes, both of which are capable of extension and contraction. The first tube is always visible; but the second, which is the proper organ of respiration, is exerted only when the water is raised to a certain

certain height. Through this tube the air is conveyed into two large tracheae or wind-pipes within the body of the animal, and maintains the principle of life. When the tails are below the surface, they occasionally emit small bubbles of air, which are visible to the naked eye; and immediately repair to the surface for fresh supplies. These rat-tailed worms pass the first and longest part of their lives under water; when near the time of their transformation, they leave the water, go under the ground, and are there transformed into chrysalids; and, lastly, from this state they are transformed into flies, and spend the remainder of their existence in the air.

Another species of aquatic worms merit attention. They frequent marshes, ditches, and stagnating waters. Their general colour is a greenish brown. Their bodies consist of eleven rings and their skin is not crustaceous, but rather resembles parchment. Though these animals, before their transformation into flies, live in water, air is necessary to support their principle of life; and the apparatus with which Nature has furnished them for that important purpose deserves our notice. The last ring, or termination of their bodies, is open, and serves as a conductor of
air.

air. From this last ring proceed a number of hairs, which, when examined by the microscope, are found to be real feathers with regular vanes. In particular situations, they bend the last ring in such a manner as to reach the surface of the water or mud in which they are placed. These feathers prevent the water from entering into the tube, or organ of respiration; and, when the animal raises the termination of its body to the surface, in order to receive air, it erects and spreads the feathers, and by this means exposes the end of the tube to the atmosphere. When cautiously cut open, two large vessels, or tracheae, appear on each side, and occupy almost one half of the body. Both of these wind-pipes terminate in the open tube, or last ring. Though these worms are furnished with organs of respiration, and actually respire air, yet M. de Reaumur discovered that some of them could live more than than twenty-four hours without respiration.

So anxious is Nature to provide animals, in every state of their existence, with air, that, after the transformation of many insects into chrysalids, she creates instruments for that purpose, which did not exist previous to their transformation. The rat-tailed worms, formerly

merly mentioned, soon after they are transformed into chrysalids, instead of a soft pliable skin, are covered with a hard crustaceous substance, seemingly impervious to the air; and the tail, which was the wind-pipe of the animal in its first state, gradually vanishes. In a few hours, however, four hollow horns shoot out, two from the fore, and two from the hind, part of what was the head of the animal. These horns, which are hard and tubular, M. de Reaumur discovered to be real wind-pipes, destined for the introduction of air into the chrysalis, a state in which the animals have the appearance of being almost totally dead, and, of course, should seem to have little use for respiration. He likewise discovered that these horns, which had pierced the hard exterior covering, terminated in as many tracheae in the body of the animal. This fact affords a strong example of the necessity of air for sustaining the principle of life, even in its lowest condition. After these animals pass from the chrysalis state to that of flies, they are deprived both of their tails and horns. But Nature, in this last stage of their existence, has not left them without proper resources for the introduction of air into their bodies. Instead of protuberant tracheae in
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the form of tails or horns, they now, like other flies, receive air by means of stigmata, or holes, variously disposed over different parts of the body.

The nymph of the libella, or dragon-fly, respire water, in the same manner as men and quadrupeds respire air. We receive and throw out the air by the mouth and nostrils. But the nymphs of the libella receive and eject water by an aperture at the termination of their bodies. These nymphs sometimes throw out the water, at certain intervals, with such force, that the stream is perceptible at the distance of two or three inches from their bodies. When kept some time out of the water, the desire or necessity of respiration is augmented; and, accordingly, when replaced in a vessel filled with water, inspirations and respirations are repeated with unusual force and frequency. If you hold one of these nymphs in your hand, and apply drops of water to the posterior end of its body, it instantly, by an apparatus similar to the piston of a pump, sucks in the water, and the dimensions of its body are visibly augmented. This water is again quickly thrown out by the same instrument. But, though this insect respire water, air seems to be not

the less necessary to its existence; for, like other insects, the whole interior part of its body is amply provided with large and convoluted tracheae; and, externally, there are several stigmata destined for the introduction of air*.

The worms, or nymphs, of the ephemeron flies merit attention. They have received the denomination of *ephemeron*, because almost none of them survive the day in which they are transformed into flies. But many of them live not one hour after their transformation. When in the worm and nymph states, they generally live in holes near the surface of the water; and, under these two forms, continue to grow till they are mature for passing into the last and shortest period of their existence. Swammerdam informs us, that some of them remain three years under water, others two, and others only one. During their abode in this element, they are nourished and prepared for their last and fatal change. Immediately after the males have joined their mates, and the females have deposited their eggs in the water, both perish, but not before they have left the rudiments of a numerous

* Reaumur, tom. 12. pag. 187. 12^o edit.

race of successors. As long as these insects live in the water, to inattentive observers, their general appearance is nearly the same. When they have passed however into nymphs, the vestiges of wings may be perceived, which we look for in vain during their first or worm state. In both states, the insect which is to become an ephemeron fly has six legs attached to the breast. The head is triangular, and from the base of each eye proceeds an articulated feeler. The body is composed of ten rings, from the last of which three tails, that probably perform the office of tracheae, arise. These tails, in some species, are as long as the animal's body, and are fringed with hairs which have a resemblance to feathers. But, what principally deserves our notice on this subject is, that, on each side of the body, there are six or seven protuberances, which have the appearance of so many oars. With these instruments the animals describe arches in the water, first on one side, and then on the other, with astonishing rapidity. This circumstance led Clutius, and some other authors, to think that these protuberances were fins, or instruments of motion, and that the animals were fishes. But Reaumur remarked that they moved these fins with the same rapidity when

the animals were at rest as when they were in motion; and that, instead of fins, when examined by the microscope, he discovered them to be gills, through which the creatures respire. Each gill consists of a short trunk, and two large branches, or tubes, which give off on all sides a number of smaller ramifications, and are perfectly similar to the tracheae of other insects. At the origin of every gill, two tracheae penetrate the trunk, and are dispersed through the body of the animal.

Though the stigmata, or respiratory organs, of caterpillars and other insects, were long known to serve the purpose of inspiration, yet it was uncertain whether the animals respired by the same orifices, till Bonnet, and, after him, Reaumur, ascertained the fact by many curious and accurate experiments. The first of these authors immersed numbers of caterpillars, of different kinds, and at different times, in water, and he observed, both with the naked eye, and by the assistance of a glass, bubbles of air issuing from various parts of their bodies, and particularly from the stigmata. To remove all deception from his experiments, before immersion, he carefully moistened the caterpillars with water, in order

der to dislodge any portions of the external air that might be adhering to their bodies. Some of them he allowed to remain so long under water, that they had every appearance of death. He then raised the head and the two anterior stigmata above the surface. The head, and first pair of legs, soon began to move from side to side; and the body necessarily partook of the same motions. During these movements, many bubbles of air issued from the posterior and intermediate stigmata, which still remained under water; but the membranous limbs continued nearly at rest. He next kept a caterpillar under water till all motion was suspended. Then he elevated the anus and the two last stigmata above the surface, that they might have a communication with the external air. He kept the animal in this situation about half an hour, without any symptoms of re-animation. After raising the body successively from the last to the first pair of stigmata, still the animal exhibited no symptoms of life; but, when he exposed the whole body to the external air for half an hour, the powers of life completely returned. After suspending the caterpillar about two hours with the last five pair of stigmata above the surface, he found that life

was

was not extinguished. He then raised the water till the anus and last pair of stigmata only were exposed to the atmosphere. He allowed the caterpillar to remain in this situation more than half an hour; and he observed that it often bended its body with a view to reach the surface, and that, during these efforts, bubbles of air issued from the anterior, but not from the posterior stigmata. He likewise remarked, that, on the smallest motion of the animal, these bubbles were discharged, but that they were augmented both in quantity and size, in proportion to the agitations of the body. M. Bonnet immediately raised the water till it covered the two last stigmata; the caterpillar was violently agitated; but no bubbles of air, the communication being cut off, appeared, and all motion ceased. He instantly lowered the water, and exposed the two posterior stigmata to the air; the animal resumed its movements; but in a moment after it expired. By another experiment, M. Bonnet discovered that a caterpillar lived eight days suspended in water, during all which time it breathed solely by the two posterior stigmata.

After these and many other facts of a similar kind, which demonstrate that air is necessary

cessary for the support and continuation of animal life, it shall only be remarked, that, when caterpillars undergo their last change, and appear in the form of flies of every denomination, Nature has still furnished them with stigmata, or respiratory organs.

Reptiles of all kinds are likewise furnished with organs of respiration. Land snails, at the approach of winter, bury themselves in the earth, or retire into holes of rocks, or of old buildings, where they remain in a torpid state during the severity of the season. For protection and warmth, these animals, when they go into their winter habitations, form, by means of a slime or saliva that issues from every pore of their bodies, a membranous cover which stops up the mouths of their shells. But this pellicle or cover, though apparently pretty hard and solid, is so thin and porous as not entirely to exclude the entrance of air, without which the principle of life could not be continued. Accordingly, when, by accident, the pellicle is made too thick, and prevents a communication with the external air, the animal, to remedy the evil, makes a small aperture in its cover. In this state snails remain six or seven months, without food or motion, till the genial warmth
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of the spring breaks their slumber, and calls forth their active powers. Hence it should appear, that air is more necessary to the preservation of animal life than food itself; for, in numberless instances, animals can live, not for days or weeks, but for months, without supplies of nourishment. None of them, however, are capable of existing nearly so long without having some communication with the air.

With regard to snails that live in fresh waters, or in the ocean, the species of which are numerous, their manner of respiring is singular. All of them have an aperture on the right side of the neck. This aperture serves the complicated purposes of discharging the faeces, of lodging the organs of generation, of ascending and descending in the water, and of respiration. They are frequently observed to straiten the orifice of this aperture, to stretch it out in the form of an oblong tube; and, in this state, they rise to the surface, in order to expel the former air, and take in a new supply.

But, though air seems to be an indispensable principle of animal life, yet many animals can live longer without the use of this element, or at least with smaller quantities of it,

it, than others. Even men, by long practice, acquire the faculty of retaining the air in their lungs for an almost incredible length of time. Some of those wretched creatures who are compelled by tyranny to dive for pearl-oysters, have been known to continue under water three quarters of an hour without receiving a fresh supply of air. Those animals which lie torpid during the winter, as the hedge-hog, the dormouse, the marmot, &c. though perhaps not entirely deprived of all communication with the air, exist, without any apparent breathing, till the heat of the spring restores their wonted powers of life, when the respiration of air becomes again equally necessary as before their torpor commenced. The toad, like all the frog-kind, is torpid in winter. At the approach of winter, the toad retires to the hollow root of a tree, to the cleft of a rock, and sometimes to the bottom of a ditch or pond, where it remains for months in a state of seeming insensibility. In this last situation, it can have very little communication with the air. But still the principle of life is continued, and the animal revives in the spring. What is more wonderful, toads have been found, in a hundred places of the globe, inclosed in the heart of solid

solid rocks, and in the bodies of trees, where they have been supposed to exist for centuries, without any apparent access either to nourishment or to air; and yet they were alive and vigorous. In the *Memoirs of the Academy of Sciences* for the year 1719, we have an account of a toad found alive, and healthy, in the heart of an old elm. Another, in the year 1731, was discovered, near Nantz, in the heart of an old oak, without any visible entrance to its habitation. From the size of the tree, it was concluded, that the animal must have been confined in that situation at least eighty or a hundred years. In the many examples of toads found in solid rocks, exact impressions of the animals bodies, corresponding to their respective sizes, were uniformly left in the stones or trees from which they were dislodged; and, to this day, it is said, that there is a marble chimney-piece at *Chatworth* with a print of a toad in it; and a traditionary account of the place and manner in which it was discovered.

These, and similar facts, are supported by authorities so numerous and so respectable, that it is unnecessary to quote them. Many abortive attempts have been made to account for an animal's growing and living very long
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in the situations above described, without the possibility of receiving nourishment or air; especially as, like all other animals, when put into an exhausted receiver, the toad soon loses its existence. Upon this subject I shall only hazard two observations. The toad, it is well known, when kept in a damp place, can live several months without food of any kind, though, in its state of natural liberty, it devours voraciously spiders, maggots, ants, and other insects. Here we have an instance, and there are many, of an animal whose constitution is so framed by Nature, that it can exist several months without receiving any portion of food. According to our ideas of the necessity of frequent supplies of nourishment, it is nearly as difficult for us to conceive an abstinence of four or six months as one of as many years, or even centuries. The one fact, therefore, though we are unable to account for either, may be as readily admitted as the other. The same remark is equally applicable to the regular respiration of air. The toad, and many other animals, from some peculiarity in their constitution, can live very long in a torpid state without seeming to respire, and yet their principle of life is not entirely extinguished.

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Hence the toad may, and actually does, live many years in situations which exclude a free intercourse with the external air. Besides, almost all the above, and similar facts, must, from their nature, have been discovered by common labourers, who are totally unqualified for examining every circumstance with the discerning eye of a philosopher. In rocks there are many chinks, as well as fissures, both horizontal and perpendicular; and in old trees nothing is more frequent than holes and vacuities of different dimensions. Thro' these fissures and vacuities the eggs of toads may accidentally be conveyed by water, the penetration of which few substances are capable of resisting. After the eggs are hatched, the animals may receive moisture, and small portions of air, through the crevices of rocks, or the channels of aged trees. But I mean not to persuade; for I cannot satisfy myself. All I intend is to recommend, to those gentlemen who may hereafter chance to see such rare phaenomena, a strict examination of every circumstance that can throw light upon a subject so dark and mysterious; for the vulgar, ever inclined to render uncommon appearances still more marvellous, are not to be trusted.

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From the facts I have enumerated, it is apparent that air, in certain proportions, according to the structure and constitution of every animated being of which we have any knowledge, is indispensibly necessary for the existence and continuation of animal life. Not only men, quadrupeds, birds, fishes, reptiles, and the larger insects, but even fleas, mites, the minute eels found in paste or in vinegar, and the animalcules produced by infusing animal or vegetable substances in water, inevitably perish when deprived of this all-vivifying element.

With regard to plants, air is so necessary to their existence, that they do not vegetate in an exhausted receiver. Plants, as formerly mentioned, are furnished with numerous air-vessels, or respiratory organs. They absorb and transmit air through every pore. When placed in an exhausted receiver, the air contained in every part of their substance is soon extracted; and, in proportion as this air is likewise pumped out by the machine, the flowers and leaves show evident symptoms of debility; they become flaccid, pendulous, and assume a sickly appearance; and, if retained in that situation a certain length
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of time, their vegetating powers are irrecoverably extinguished.

Upon the whole, as the air we continually breathe is an universal menstruum, and, of course, liable to be impregnated with exhalations from every substance to which it has access, the great importance of personal, as well as of domestic cleanliness, is an obvious reflection. In building towns or houses, the situation, with regard to air, is a capital object. The vicinity of marshes, of stagnating waters, of manufactures of tallow, oil, sal ammoniac, the smelting or corroding of metals of every kind, and many other operations which contaminate the air, should be either avoided or removed, as they are the pests of our senses, and the poisoners of our constitutions. Even in northern climates, houses surrounded with trees, or in the neighbourhood of luxuriant vegetables, are always damp, and infested with insects; and hence the ambient air is replete with the seeds of disease. Precautions of this kind are still more necessary in hot climates. Air, like other menstrooms, absorbs a greater or less proportion of the particles of bodies, according to its degree of heat. In Madrid, however,

ever, in Constantinople, and in many other cities of warm regions, the houses are crowded together, the streets are narrow, and covered with filth of every kind. We cannot, therefore, be surprised, that human beings existing in such situations should be so frequently infected with pestilential diseases.

CHAPTER IV.

Of Motion.

MOTION, in the opinion of Aristotle, and the admirers of ancient philosophy, can only be produced by mind; and hence they define *mind* to be the *power of moving*. By the same mode of reasoning, it may be said that *rest* or *inactivity*, is the *power of being moved*. But such speculations are foreign to the nature of this work, and perhaps fruitless in themselves. Though it is impossible to give an unexceptionable definition of motion, the phænomenon itself is obvious to every man's senses.

All the terrestrial objects which present themselves to our observation are, with regard to motion, distinguishable into two general classes. The first consists of those which are endowed with a spontaneous or self-moving power, and with some qualities and affections similar to those of our minds. The second consists of all those objects in which no such qualities and affections appear, and are of a nature so passive, that they never
move

move of themselves, nor, when put in motion do they ever stop without some external influence or resistance. The first class of objects, from their possessing the power of spontaneous motion, and other qualities peculiar to animated beings, are easily distinguished from body, or matter, which is totally deprived of all these qualities. In consequence of its passive nature, matter not only never changes its state without external force, but resists when any such change is attempted to be made. When at rest, it cannot be put in motion without difficulty; and, when in motion, a certain force is required to stop its course. The force with which matter perseveres in its state, and resists any change, is called its *vis inertiae*, and is always proportional to the quantity of matter in any particular body. When we double or triple a body, we uniformly find, that the force requisite to move it with equal celerity must likewise be doubled or tripled. These, and similar facts, which are results of perpetual experience, show that body is equally indifferent to motion and rest; that this indifference seems to be the natural consequence of the most absolute inactivity; and that the power of beginning motion is peculiar to ac-

tive and intelligent beings. Leaving therefore, all metaphysical speculations on this subject, we shall give some remarks upon the motions of animals.

In general, all the progressive motions of animals are performed by the instrumentality of muscles, tendons, and articulations. The operation of muscles depends upon some unknown influence derived to them from the brain and nerves. Hence the brain and nerves are the sources of every motion as well as of every sensation. With regard to the causes which determine the actions of animals, these must be referred to sensation, and the consequent exertions of intellect. The first impression an object makes upon our sensations stimulates us either to approach or retire from it, according as it excites affection or aversion. These motions necessarily result from the first impression made by the object. But man, and many other animals, have the power of resisting these original motives to action, and of remaining at rest, without either retiring or approaching. ‘ If a man,’ says the Count de Buffon, ‘ were deprived of sight, he would make no movement to gratify his eyes. The same thing would happen, if he were deprived of any of the other

‘ other senses; and if deprived of every sense,
 ‘ he would remain perpetually at rest, and
 ‘ no object would excite him to move, though,
 ‘ by natural conformation, he were fully ca-
 ‘ pable of motion.’ Natural wants, as that
 of taking nourishment, necessarily excite de-
 sire or appetite. But, if a man be deprived
 of sensation, want cannot exist, because all
 its sources are annihilated. This is cutting
 off all the causes, and at the same time look-
 ing for the effects. An animal without some
 sensation is no animal, but a dead mass of
 matter. Sentiment is the only stimulus to
 animal motion; the aptness of the parts pro-
 duces the effect, which varies according to
 the structure and destination of these parts.
 The sense of want creates desire. Whenever
 an animal perceives an object fitted to sup-
 ply its wants, desire is the necessary conse-
 quence, and action or motion instantly suc-
 ceeds.

Beside progressive motion, the motion of
 hands, and other parts of animal bodies,
 which are all effected by means of muscles,
 and are subject to the will of the creatures
 who perform them, there are other motions
 that have little or no dependence on our in-
 clinations. Of this kind are the action of the
 P 2 heart,

heart, the circulation of the blood, the digestion of food, the peristaltic motion of the bowels, the progress of the chyle from the stomach and intestines to the subclavian vein, the movement of the various secreted liquors, such as the gall, the urine, the saliva, &c. These, together with the action of the lungs in respiration, have received the denomination of *vital* and *involuntary motions*, because most of them go on without any conscious exertions of the intellectual principle. If such a variety of nice and complicated movements had been left to the determination and direction of our minds, they must necessarily have occupied too much of our attention; and many of them would infallibly have been neglected during sleep, when consciousness is often almost totally suspended. But Nature in her operations is always wise. She has given to man, and other animals, the direction of no movements but what are easily performed, contribute to pleasure and health, and enable them to acquire food corresponding to the structure of their bodies and the elements in which they live.

It never was my intention, and, indeed, it would have been foreign to the design of this work, and ill suited to that class of mankind

kind to whom I wish chiefly to be useful, to enter into the *rationale* of animal motion; to mention the number, insertion, and direction of the muscles employed in moving the different parts of animated bodies; or to account for the modes by which animals walk, leap, fly, swim, creep, &c. Such discussions would not only require a Volume, but a thorough acquaintance with all the depths of anatomical and mathematical knowledge. What follows, therefore, will consist of some desultory observations; and the subject shall be concluded by enumerating a few examples of movements peculiar to certain animals.

The motions of animals are proportioned to their weight and structure. A flea can leap some hundred times its own length. Were an elephant, a camel, or a horse, to leap in the same proportion, their weight would crush them to atoms. The same remark is applicable to spiders, worms, and other insects. The softness of their texture, and the comparative smallness of their specific gravity enable them to fall with impunity from heights that would prove fatal to larger and heavier animals.

Motion gives birth, perfection, death, and reproduction,

reproduction, to all animal and vegetable beings. It is the cause of all that diversity and change which perpetually affect every object in the universe. The globe we inhabit, as well as the innumerable and stupendous heavenly bodies which present themselves, in forms apparently minute to our observation, constantly exhibit motions of the most inconceivable rapidity. The magnitude of this earth, when considered with relation to man, and other animals, appears to be exceedingly great. It is indeed sufficiently spacious, and sufficiently prolific, for the conveniency and maintenance of its inhabitants. The magnificent objects displayed on its surface excite the admiration of every beholder. Its plains and mountains, its rivers and lakes, its islands and continents, its seas and oceans, continually solicit attention, gratify curiosity, and call forth the powers of reason and reflection. But, when compared to the other heavenly bodies, the number and magnitude of which exceed all the powers of human conception, the grandeur of our earth diminishes. Instead of exciting wonder, it almost vanishes from our sight. Instead of an immense globe, it dwindles into a point, seems to occupy no space, and
loses

loses itself in the boundless regions of the universe. Considerations of this kind are apt to depress the dignity of man, and to lessen his importance in the great scale of being; but they expand his mental faculties, and exalt his ideas concerning that inconceivable Power which first produced, and still supports, those astonishing orbs.

The different movements to which animals are stimulated by the desire of food, by love, by the appetite for frolic and exercise, by their hostilities, and by other exciting causes, give animation and vivacity to the whole scene of nature. A silent and motionless prospect, however beautiful and variegated, soon ceases to please, and at last becomes insupportable. Motion, says Mr Harris, is the object or cause of all sensation. In music we hear it; in flavours we taste it; in odors we smell it; in touch we feel it; in light we see it.

Animals furnished with destructive weapons, or endowed with uncommon strength, courage, or ingenuity, are proportionally slower in their movements than the weaker kinds. The same remark is applicable to those species whose food is always at hand. Worms, caterpillars, and many other insects,
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in order to procure nourishment, are under no necessity of taking an extensive range. But the motions of birds and fishes are extremely rapid; because, in quest of food, they are obliged to pass through large tracks, and they have also many enemies to avoid.

Timid animals, as the hare, the rabbit, the Guiney-pig, &c. are almost perpetually in motion. Even when perfectly undisturbed, they are restless, and betray a continual anxiety of danger. They run about, stop short, erect their ears, and listen. The Guiney-pig frequently raises itself on its hind-legs, and snuffs all around to catch the scent of food when hungry, or to encrease its circle of hearing when afraid.

The movements of many animals are so extremely slow, that some of them, particularly those of the shell tribes, are generally supposed to be destitute of the power of moving. It is a common notion, that both fresh and salt water muscles have not the loco-motive faculty. But this is a vulgar error. It is almost unnecessary to mention, that the exterior part of muscles consists of two shells hinged together, which the animals can open or shut at pleasure. Every person must likewise have observed, in the structure of the
animal

animal itself, a fleshy protuberance of a much redder colour, and denser consistence, than the other parts of the body. This muscular protuberance, which consists of two lobes, has been denominated a *trunk*, or *tongue*: But it is an instrument by which the creature is enabled to perform a progressive, though a very slow motion; and, therefore, in describing its manner of moving, I shall call these two lobes the animal's *tentacula*, or *feet*.

When inclined to remove from its present situation, the river-muscle opens its shell, thrusts out its tentacula, and, while lying on its side in an horizontal position, digs a small furrow in the sand. Into this furrow, by the operation of the same tentacula, the animal makes the shell fall, and thus brings it into a vertical position. We have now got our muscle on end; but how is he to proceed? He stretches forward his tentacula, by which he throws back the sand, lengthens the furrow, and this fulcrum enables him to proceed on his journey.

With regard to marine muscles, their progressive motion is performed in the same manner, and by the same instruments. When not in motion, they are all firmly attached to rocks, or small stones, by many threads of
about

about two inches in length, which serve the double purposes of an anchor and cable. Without this provision of Nature, these animals must become the sport of the waves, and the species would soon be annihilated. But, how does the creature spin these threads? A cylindrical canal extends from the origin to the extremity of the tentacula. In this canal an extremely glutinous substance is secreted, which the animal, by the operation of certain muscles, has the power of forcing out, and of attaching it, in the form of strong threads, to stones or other solid bodies. More than a hundred and fifty of these cables are often employed in mooring a single muscle *. The substance of the threads is exceedingly viscid, indigestible in the human stomach, and is probably the cause of those fatal consequences which sometimes happen to inattentive eaters. In Scotland, these threads are called the *beards* of muscles, and should be carefully pulled off before the animals are thrown into the stomach.

Other bivalved shell-fishes, the species of which are numerous, perform a progressive or retrograde motion by an instrument that

* Oeuvres de Bonnet, tom. 5. pag. 361. 4to. edit.

has no small resemblance to a leg and foot. But the animals can, at pleasure, make this leg assume almost every kind of form, according as their exigencies may require. By this leg they are not only enabled to creep, to sink into the mud, or disengage themselves from it, but to perform a motion, which no man could suppose shell-fishes were capable of performing. When the tellina, or limpin, is about to make a spring, it puts the shell on the point or summit, as if with a view to diminish friction. It then stretches out the leg as far as possible, makes it embrace a portion of the shell, and, by a sudden movement, similar to that of a spring let loose, it strikes the earth with its leg, and actually leaps to a considerable distance*.

The spout-fish † has a bivalved shell, which resembles the handle of a razor. This animal is incapable of progressive motion on the surface; but it digs a hole or cell in the sand, sometimes two feet in depth, in which it can ascend and descend at pleasure. The instrument or leg by which it performs all its movements is situated at the centre. This

* Oeuvres de Bonnet, tom. 5. pag. 341. 4to. edit.

† The name of the animal in Scotland. In England it is called *razor-fish*.

leg is fleshy, cylindrical, and pretty long. When necessary, the animal can make the termination of the leg assume the form of a ball. The spout-fish, when lying on the surface of the sand, and about to sink into it, extends its leg from the inferior end of the shell, and makes the extremity of it take on the form of a shovel, sharp on each side, and terminating in a point. With this instrument the animal cuts a hole in the sand. After the hole is made, it advances the leg still farther into the sand, makes it assume the form of a hook, and with this hook, as a fulcrum, it obliges the shell to descend into the hole. In this manner the animal operates till the shell totally disappears. When it chooses to regain the surface, it puts the termination of the leg into the shape of a ball, and makes an effort to extend the whole leg; but the ball prevents any farther descent, and the muscular effort necessarily pushes the shell upward till it reaches the surface, or top of the hole. It is amazing with what dexterity and quickness these seemingly awkward motions are performed.

It is remarkable that the spout-fish, though it lives in salt water, abhors salt. When a little salt is thrown into the hole, the animal
instantly

instantly quits his habitation. But it is still more remarkable, that, if you seize the animal with your hand, and afterwards allow it to retire into its cell, you may strew as much salt upon it as you please, but the fish will never again make its appearance. If you do not handle the animal, by applying salt, you may make it come to the surface as often as you incline; and fishermen often make use of this stratagem. This behaviour indicates more sentiment and recollection than one should naturally expect from a spout-fish.

The scallop, another well known bivalved shell-fish, has the power of progressive motion upon land, and likewise of swimming on the surface of the water. When this animal happens to be deserted by the tide, it opens its shell to the full extent, then shuts it with a sudden jerk, by which it often rises five or six inches from the ground. In this manner it tumbles forward till it regains the water. When the sea is calm, troops, or little fleets of scallops, are often observed swimming on the surface. They raise one valve of their shell above the surface, which becomes a kind of sail, while the other remains under the water, and answers the purpose of an anchor, by steadying the animal, and preventing its
being

being overfet. When an enemy approaches, they instantly fhut their fhells, plunge to the bottom, and the whole fleet difappears. By what means they are enabled to regain the furface, we are ftill ignorant.

With regard to the locomotive faculty of the oyfter, the following facts are recorded in the *Journal de Phyfique* by the Abbé Dicquemare. Like many other bivalved fhell-fifh, the oyfter has the power of fquirting out water with a confiderable force. By thus fuddenly and forcibly ejectiong a quantity of water, the animal repulfes fuch enemies as endeavour to infinuate into its fhell while open. By the fame operation, if not firmly attached to rocks, to ftones, or to one another, the oyfter retreats backwards, or ftarts to a fide in a lateral direction. Any perfon may amufe himfelf with the fquirting and motions of oyfters, by putting them in a plate fituated in a horizontal pofition, and which contains as much fea-water as is fufficient to cover them. The oyfter has been represented by many authors as an animal deftitute not only of motion, but of every fpecies of fenfation. The Abbé Dicquemare, however, has fhown, that it can perform movements perfectly confonant to its wants, to the dangers
it

it apprehends, and to the enemies by which it is attacked. Instead of being destitute of all sensation, oysters are capable of deriving knowledge from experience. When removed from situations which are constantly covered with the sea, devoid of experience, they open their shells, lose their water, and die in a few days. But, even when taken from similar situations, and laid down in places from which the sea occasionally retires, they feel the effects of the sun's rays, or of the cold air, or perhaps apprehend the attacks of enemies, and accordingly learn to keep their shells close till the tide returns. Conduct of this kind plainly indicates both sensation and a degree of intelligence.

The progressive motion of the sea-urchin, or sea-egg, a well known multivalved shell-fish, merits our attention. This animal, of which there are several species, is round, oval, or shaped like a bias-bowl. The surface of the shell is divided into beautiful triangular compartments, and covered with numberless prickles; from which last circumstance it has received the appellation of *sea-urchin*, or *sea-hedge-hog*. These triangles are separated by regular belts, and perforated by a great number of holes. Each hole gives
lodge.

lodgement to a fleshy horn similar to those of the snail, and susceptible of the same movements. Like the snail, the sea-urchin uses its horns when in motion; but their principal use is to fix the animal to rocks, stones, or the bottom of the ocean. By means of the horns and prickles, which proceed from almost every point of the shell, the sea-urchin is enabled to walk either on its back or on its belly. The limbs it most generally employs are those which surround the mouth. But, when it chooses, it can move forward, by turning on itself like the wheel of a coach. Thus the sea-urchin furnishes an example of an animal employing many thousand limbs in its various movements. The reader may try to conceive the number of muscles, of fibres, and of other apparatus, which are requisite to the progressive motion of this little animal.

The motion of that species of medusa, or sea-nettle, which attaches itself to rocks, and to the larger shell-fish, is extremely slow. The sea-nettles assume such a variety of figures, that it is impossible to describe them under any determinate shape. In general, their bodies have a resemblance to a truncated cone. The base of the cone is applied to the rock, or other substance to which they adhere.

here. With regard to colour, some of them are red, some greenish, some whitish, and others are brown. When the mouth, which is very large, is expanded, its margin is surrounded with a great number of fleshy filaments, or horns, similar to those of the snail. These horns are disposed in three rows around the mouth, and give the animal the appearance of a flower. Through each of these horns the sea-nettle squirts water, like so many jets-d'eau. What is peculiar in the structure of these creatures, the whole interior part of their body, or cone, is one cavity or stomach. When searching for food, they extend their filaments, and entangle any small animals they encounter. When they meet with their prey, they instantly swallow it, and shut their mouths close like a purse. Though the animal should not exceed an inch, or an inch and a half, in diameter, as it is all mouth and stomach, it swallows large whelks and muscles. These shell-animals sometimes remain many days in the stomach before they are ejected. Their nutrifying parts are at last, however, extracted; but how does the sea-nettle get quit of the shell? The creature has no other aperture in its body but the mouth, and this mouth is the in-

strument by which it both receives nourishment, and discharges the excrement, or unprofitable part of its food. When the shell is not too large, the sea-nettle has the power of turning its inside out, and by this strange manoeuvre the shell is thrown out of the body, and the animal resumes its former state. But, when the shell presents itself in a wrong position, the animal cannot discharge it in the usual manner; but, what is extremely singular, near the base of the cone, the body of the creature splits, as if a large wound had been made with a knife, and through this gash the shell of the muscle, or other shell, is ejected.

With regard to the progressive motion of the sea-nettle, it is as slow as the hour-hand of a clock. The whole external part of its body is furnished with numerous muscles. These muscles are tubular, and filled with a fluid, which makes them project in the form of prickles. By the instrumentality of these muscles, the animal is enabled to perform the very slow motion just now mentioned. But this is not the only means by which the sea-nettle is capable of moving. When it pleases, it can loosen the base of the cone by which it is attached to the rock, reverse its body, and

and employ the filaments round its mouth as so many limbs. Still, however, its movements are imperceptibly slow. For these facts several authors might be quoted; but we shall refer the reader solely to M. de Bonnet*.

Before we conclude this chapter, we shall just mention a mode of flying which is peculiar to certain insects. The *mason-bee*, which is one of the solitary species, has received that appellation, because it constructs a nest with mud or mortar. Externally, this nest has no regular appearance; and is, therefore, generally regarded as a piece of dirt accidentally adhering to a wall. This habitation, however unseemly in its exterior aspect, is furnished with regular cells, and often gives rise to great conflicts. When the real proprietor is abroad in quest of materials to finish the nest, a stranger takes possession. At meeting, a battle always ensues. This battle is fought in the air. Sometimes they fly with such rapidity and force against each other, that both parties fall to the ground. But, in general, like birds of prey, the one endeavours to rise above the other, and to give a

* Oeuvres de Bonnet, 4to. edit. tom. 5. pag. 345.

downward blow. To avoid the stroke, the undermost, instead of flying forward or laterally, is frequently observed to fly backward. This retrograde flight is likewise performed occasionally by the common house-fly, and some other insects, though we are unable to perceive what stimulates them to employ this uncommon movement.

CHAPTER V.

Of the instinct of Animals—Division of Instincts—Examples of Pure Instinct—Of such Instincts as can accommodate themselves to peculiar circumstances and situations—Of Instincts improveable by observation and experience—Some remarks and conclusions from this view of Instinct.

MANY theories have been invented with a view to explain the instinctive actions of animals; but none of them have received the general approbation of Philosophers. This want of success in the investigation of a subject so curious and so interesting must be owing to the operation of some powerful causes. Two of these causes appear to be a want of attention to the general oeconomy and manners of animals, and mistaken notions concerning the dignity of human nature. From perusing the compositions of most authors who have written upon animal instinct, it is evident, that they have chiefly derived their ideas, not from the various mental qualities discoverable in different species of animals, but

but from the feelings and propensities of their own minds. Some of them, at the same time, are so averse to allow brutes a participation of that intellect which man possesses in such an eminent degree, that they consider every animal action to be the result of pure mechanism. But the great source of error on this subject is the uniform attempt to distinguish instinctive from rational motives. I shall, however, endeavour to show that no such distinction exists, and that the reasoning faculty itself is a necessary result of instinct.

The proper method of investigating subjects of this kind, is to collect and arrange the facts which have been discovered, and to consider whether these facts lead to any general conclusions. This method I have adopted; and shall therefore exhibit examples of pure instincts; of such instincts as can accommodate themselves to peculiar circumstances and situations; and of instincts improveable by observation and experience. In the last place, I shall draw some conclusions.

I. *Of Pure Instincts.*

By *pure* instincts, I mean those, which, independent of all instruction or experience, instantaneously produce certain actions when
parti-

particular objects are presented to animals, or when they are influenced by peculiar feelings. Of this class the following are examples.

In the human species, the instinct of sucking is exerted immediately after birth. This instinct is not excited by any smell peculiar to the mother, to milk, or to any other substance; for infants suck indiscriminately every thing brought into contact with their mouths. The desire of sucking, therefore, is innate, and coeval with the appetite for air.

The voiding of urine and excrement, sneezing, retraction of the muscles upon the application of any painful stimulus, the moving of the eye-lids, and other parts of the body, are likewise effects of original instincts, and essential to the existence of young animals.

The love of light is exhibited by infants at a very early period. I have remarked evident symptoms of this attachment on the third day after birth. When children are farther advanced, marks of the various passions gradually appear. The passion of fear is discoverable at the age of two months. It is called forth by approaching the hand to the child's eye, and by any sudden motion or unusual noise. I once instituted a course of
expe-

experiments to ascertain the periods when the various passions, principles, or propensities, of the human mind are unfolded, and to mark the causes which first produced them. But, in less than five months after the birth of the child, the business became too complicated and extensive for the time I had to bestow on subjects of this nature.

The brute creation affords innumerable examples of pure instincts.

When caterpillars are shaken off a tree in every direction, all of them instantly turn toward the trunk, and climb up, though they had never formerly been on the surface of the ground.

Young birds open their mouths upon hearing any kind of noise, as well as that of their mother's voice. They have no apprehensions of harm; neither do they offer to use their wings till they acquire more strength and experience. The lion's cub is not ferocious till he feels force and activity for destruction.

Insects invariably deposit their eggs in situations most favourable for hatching and affording nourishment to their future progeny. Butterflies, and other insects, whose offspring feed upon vegetables, uniformly fix their eggs upon such plants as are most agreeable to the
palate

palate and constitution of their young. Water insects never deposit their eggs on dry ground. I have seen butterflies which had been transformed in the house exhibit marks of the greatest uneasiness because they could not find a proper nidus for their eggs; and, when every other resource failed, they pasted the eggs on the panes of the window.

Some species of animals look not to future wants. Others, as the bee and the beaver, are endowed with an instinct which has the appearance of foresight. They construct magazines, and fill them with provisions.

The common bees attend the female, or queen, do her many little services, and even feed her with honey from their trunks*. When deprived of the female, all their labours cease†, till a new one is obtained, whom they treat with much respect, and renew their usual operations‡. They make cells of three different dimensions, for holding workers, drones, and females; and the queen-bee, in depositing her eggs, distinguishes the three different kinds, and never puts a royal or a drone egg into the cells destined for the reception of the working bees. What is equal-

* Reaumur, 12mo edit. vol. 9. pag. 300.

† Ibid. pag. 320.

‡ Ibid. pag. 340.

ly singular, the number of these cells is proportioned to that of the different bees to be produced. One royal cell weighs as much as one hundred of the common kind ||. When there are several females in a hive, the bees work little till they have destroyed all the females but one. If more than a single female were allowed to remain in a hive, a greater number of eggs would be laid than the working bees are able to make cells for receiving.

The wood-piercing bee, which is one of the solitary species, gnaws, with amazing dexterity and perseverance, a large hole in old timber. After laying her eggs in the cells, she deposits such a quantity of glutinous matter as nourishes the worms produced from these eggs till the time of their transformation into flies. She then pastes up the mouth of the hole, and leaves her future offspring to the provision she has made for them.

The bees of that species which build cylindrical nests with rose-leaves, exhibit a very peculiar instinct. They first dig a cylindrical hole in the earth. When that operation is finished, they go in quest of rose-bushes;

|| Reaumur, tom. 10. pag. 124.

and, after selecting leaves proper for their purpose, they cut oblong, curved, and even round pieces, exactly suited to form the different parts of the cylinder*.

The solitary wasp digs holes in the sand. In each hole she deposits an egg. But how is the worm, after it is hatched, to be nourished? Here the instinct of the mother merits attention. Though she feeds not upon flesh herself, and certainly knows not that an animal is to proceed from the egg, and far less that this animal must be nourished with other animals, she collects ten or twelve small green worms, which she piles one above another, rolls them up in a circular form, and fixes them in the hole in such a manner that they cannot move. When the wasp-worm is hatched, it is amply stored with the food Nature has destined for its support. The green worms are devoured in succession†; and the number deposited is exactly proportioned to the time necessary for the growth and transformation of the wasp-worm into a fly, when it issues from the hole, and is capable of procuring its own nourishment‡.

* Reaumur, tom. 11. pag. 138.

† Ibid. tom. 12. pag. 18. ‡ Ibid. pag. 22—32.

There are many other instances of ichneumon wasps and flies, which, though they feed not themselves upon worms, lay up provisions of these animals for the nourishment of their young; and each kind is adapted to the constitution of the worm that is to proceed from their eggs*.

Birds of the same species, unless when restrained by peculiar circumstances, uniformly build their nests of the same materials, and in the same form and situation, though they inhabit very different climates. When removed by necessity from their eggs, they hasten back to them with anxiety. They turn and shift their eggs, which has the effect of heating them equally. Ducks and geese cover up their eggs till they return to the nest. A hen sits with equal ardour upon eggs of a different species, or even upon artificial eggs. I have often contemplated with wonder an instinct of the swallow. When her offspring are very young, like other small birds, she carries their excrements out of the nest. But, after they are older, she attaches herself to the side of the nest, and, by some gestures and sounds, solicits the young to void their

* Reaumur, tom. 11. pag. 38.

excrements: One of them immediately turns round, elevates its hind parts above the edge of the nest, makes the proper effort, and the mother, before the dung is half protruded from the anus, lays hold of it with her bill, drags it out, carries it off, and drops it at a distance from the nest. In all these operations, men recognise the intentions of Nature; but they are hid from the animals who perform them.

The spider, the dermestes, and many insects of the beetle kind, exhibit an instinct of a very uncommon nature. When put in terror by a touch of the finger, the spider runs off with great swiftness: But, if he finds, that, whatever direction he takes, he is opposed by another finger, he then seems to despair of being able to escape, contracts his limbs and body, lies perfectly motionless, and counterfeits every symptom of death. In this situation I have pierced spiders with pins, and torn them to pieces, without their discovering the smallest mark of pain. This simulation of death has been ascribed to a strong convulsion, or stupor, occasioned by terror. But this solution of the phaenomenon is erroneous. I have repeatedly tried the experiment, and uniformly found, that, if the
object

object of terror be removed, in a few seconds the animal runs off with great rapidity. Some beetles, when counterfeiting death, suffer themselves to be gradually roasted, without moving a single joint.

It is unnecessary to give more examples of pure instincts. I shall therefore proceed to the second class, namely,

II. *Of instincts which can accommodate themselves to peculiar circumstances and situations.*

To this class many human instincts may be referred. But, as these instinctive propensities are likewise highly improveable by experience and observation, examples of them will fall more naturally to be given under the third class.

Those animals are most perfect whose sphere of knowledge extends to the greatest number of objects. When interrupted in their operations, they know how to resume their labours, and to accomplish their purposes by different means. Some animals have no other power but that of contracting or extending their bodies. But the falcon, the dog, and the fox, pursue their prey with intelligence and address.

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The ostrich has been accused of unnaturalness, because she leaves her eggs to be hatched by the heat of the sun. In Senegal, where the heat is great, she neglects her eggs during the day, but sits upon them in the night. At the Cape of Good Hope, however, where the degree of heat is less, the ostrich, like other birds, sits upon her eggs both day and night.

Rabbits dig holes in the ground for warmth and protection. But, after continuing long in a domestic state, that resource being unnecessary, they seldom employ this art *.

Bees, when they have not room enough for their operations, augment the depth of their honey-cells †. The female bee, when the cells are not sufficiently numerous to receive her eggs, lays two or three in each cell. But, a few days after, when the cells are increased, the working bees remove all the supernumerary eggs, and deposit them in the new constructed cells ‡.

When a wasp, in attempting to transport a dead companion from the nest, finds the load too heavy, he cuts off its head, and carries it out in two portions §.

* Gazette Liter. tom. 3. pag. 228.

† Reaumur, tom. 10. pag. 29.

‡ Ibid. pag. 240.

§ Ibid. tom. 11. pag. 241.

In countries infested with monkeys, many birds, which, in other climates, build in bushes and the clefts of trees, suspend their nests upon slender twigs, and, by this ingenious device, elude the rapacity of their enemies.

The nymphs of water-moths, commonly called *cod-bail*, cover themselves by means of gluten, with pieces of wood, straw, small shells, or gravel. It is necessary that they should always be nearly in equilibrium with the water in which they live. To accomplish this purpose, when their habitations are too heavy, they add a piece of wood, when too light a bit of gravel*.

I had a cat that frequented a closet, the door of which was fastened by a common iron latch. A window was situated near the door. When the door was shut, the cat gave herself no uneasiness. As soon as she tired of her confinement, she mounted on the sole of the window, and with her paw dexterously lifted the latch and came out. This practice she continued for years.

These examples, I hope, are sufficient.

* Bonnet, tom. 4. pag. 209.—Reaumur, tom. 5. pag. 215.

III. *The third class comprehends all those Instincts which are improveable by experience and observation.*

The superiority of man over the other animals seems to depend chiefly on the great number of instincts with which his mind is endowed. Traces of every instinct he possesses are discoverable in the brute creation. But no particular species enjoys the whole. On the contrary, most animals are limited to a small number. This appears to be the reason why the instincts of brutes are stronger, and more steady in their operation, than those of man. A being actuated by a great variety of motives must necessarily reason, or, in other words, hesitate in his choice. Its conduct, therefore, must often waver; and he will have the appearance of being inferior to another creature who is stimulated to action by a smaller number of motives. Man, accordingly, has been considered as the most vacillant and inconsistent of all animals. The remark is just; but, instead of a censure, it is an encomium on the species. The actions of a dog, or a monkey, for the same reason, are more various, whimsical, and uncertain, than those of a sheep or a cow.

Most human instincts receive improvement from experience and observation, and are capable of a thousand modifications. This is another source of man's superiority over the brutes. When we are stimulated by a particular instinct, instead of instantly obeying the impulse, another instinct arises in opposition, creates hesitation, and often totally extinguishes the original motive to action. The instinct of fear is daily counteracted by ambition or resentment; and, in some minds, fear is too powerful for resentment, or any other instinct we possess. The instinct of anger is often restrained by the apprehension of danger, by the sense of propriety, by contempt, and even by compassion. Sympathy, which is one of our most amiable instincts, frequently yields to anger, ambition, and other motives. The instinct or sense of morality is too often thwarted by ambition, resentment, love, fear, and several of what I call modified or compounded instincts, such as avarice, envy, &c.

The following are examples of modified, compounded, or extended instincts.

Superstition is the instinct of fear extended to imaginary objects of terror.

Devotion is an extension of the instinct of love to the First Cause, or Author of the Universe.

Reverence

Reverence or respect for eminent characters is a species of devotion.

Avarice is the instinct of love directed to an improper object.

Hope is the instinct of love directed to future good.

Envy is compounded of love, avarice, ambition, and fear.

Benevolence is the instinct of love diffused over all animated beings.

Sympathy is the instinct of fear transferred to another person, and reflected back upon ourselves.

In this manner, all the modified, compounded, or extended passions and propensities of the human mind, may be traced back to their original instincts.

The instincts of brutes are likewise improved by observation and experience. A young dog, like a child, requires both time and art to unfold and perfect his natural instincts. If neglected by man, he learns from his companions how to act in particular situations: But, when he enjoys both these sources of information, his talents are improved to a degree that often excites our astonishment. The same remark applies to all docile animals, as the elephant, the horse,

the camel, &c. Every man's recollection will supply him with many examples of the improveable talents of brutes; and, therefore, it is unnecessary to be more explicit.

Having exhibited instances of pure instinct, of instincts which accomodate themselves to peculiar circumstances and situations, and of instincts improveable by observation and experience, I shall now hazard a few remarks.

From the example I have given, it appears that instinct is an original quality of mind, which, in many animals, may be improved, modified, and extended, by experience; that some instincts are coeval with birth; and that others, as fear, anger, the principle of imitation, and the power of reasoning, or balancing motives, are gradually unfolded, according to the exigencies of the animal. One of the strongest instincts appears not till near the age of puberty; but by bad example, and improper situations, this instinctive desire is often prematurely excited. The minds of brutes, as well as those of men, have original qualities, destined for the preservation of the individual and the continuation of the species. The calling forth of these qualities is not instinct, but the exertion

ertion or energy of instinct. Instincts exist before they act. What man or brutes learn by experience, though this experience be founded on instinct, cannot with propriety be called instinctive knowledge, but knowledge derived from experience and observation. Instinct should be limited to such actions as every individual of a species exerts without the aid either of experience or imitation. Hence instinct may be defined, 'Every original quality of mind which produces particular feelings or actions, when the proper objects are presented to it.' These qualities or instincts vary in particular species. Some are endowed with many, and others with few. In some they are stronger, in others weaker; and their strength or weakness seems to be exactly proportioned to their number. The difference of talents among men who have had the same culture, arises from a bluntness, or absolute deprivation, of some original or modified instincts. Taste or love of particular objects, whether animated, inanimated, or artificial, is in some men so obtuse, that we often say it is entirely wanting. Insects have fewer instincts than men or quadrupeds; but the exertions of insects are so uniform and steady,

that

that they excite the admiration of every beholder.

Sensation implies a sentient principle or mind. Whatever feels, therefore, is mind. Of course, the lowest species of animals are endowed with mind: But the minds of animals have very different powers; and these powers are expressed by peculiar actions. The structure of their bodies is uniformly adapted to the powers of their minds. We never see a mature animal attempting actions which Nature has not enabled it to perform, by bestowing on it proper instruments. A bee collects the materials of honey and wax, but attempts not to gnaw rotten wood, like the wasp.—Neither does peculiarity of structure prompt the actions of brutes. Calves push with their heads long before their horns are grown. This and similar examples, shew, that the instincts of brutes exist previous to the expansion of those instruments which Nature intended they should employ.

This view of instinct is simple, removes every objection to the existence of mind in brutes, and unfolds all their actions, by referring them to motives perfectly similar to those by which man is actuated. There is, perhaps

perhaps, a greater difference between the mental powers of some animals than between those of man and the most sagacious brutes. Instincts may be considered as so many internal senses, of which some animals have a greater, and others a smaller number. These senses, in different species, are likewise more or less ductile; and the animals possessing them are, of course, more or less susceptible of improving, and of acquiring knowledge.

The notion that animals are machines, is perhaps too absurd to merit refutation. Though no animal is endowed with mental powers equal to those of man, yet there is not a faculty of the human mind, but evident marks of its existence are to be found in particular animals. Senses, memory, imagination, the principle of imitation, curiosity, cunning, ingenuity, devotion, or respect for superiors, gratitude, are all discoverable in the brute creation. Neither is art denied to them. They build in various styles; they dig; they wage war; they extract peculiar substances from water, from plants, from the earth; they modulate their voices so as to communicate their wants, their sentiments, their pleasures and pains, their apprehensions
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of danger, and their prospects of future good. Every species has its own language, which is perfectly understood by the individuals. They ask and give assistance to each other. They speak of their necessities; and this branch of their language is more or less extended, in proportion to the number of their wants. Gestures and inarticulate sounds are the signs of their thoughts. It is necessary that the same sentiments should produce the same sounds and the same movements; and, consequently, each individual of a species must have the same organization. Birds and quadrupeds, accordingly, are incapable of holding discourse to each other, or communicating the ideas and feelings they possess in common. The language of gesture prepares for that of articulation; and some animals are capable of acquiring a knowledge of articulate sounds. They first judge of our thoughts by our gestures; and afterwards acquire the habit of connecting these thoughts with the language in which we express them. It is in this manner that the elephant and the dog learn to obey the commands of their masters. Infants are exactly in the same condition with brutes. They understand some of our gestures and words long before they can articulate.

ticulate. They discover their wants by gestures and inarticulate sounds, the meaning of which the nurse learns by experience. Different infants have different modes of expressing their wants. This is the reason why nurses know the intentions of infants, though they are perfectly unintelligible to strangers. When an infant, accordingly, is transferred from one nurse to another, the former instructs the latter in the gestures and inarticulate language of the child.

The idea of a *machine* implies a select combination of the common properties of matter. The regularity of its movements is a proof that they are totally distinct from animal or spontaneous motion. A machine has nothing analogous to sensation, which is the lowest characteristic of an animal. An *animated machine*, therefore, is an absurd abuse of terms. It confounds what Nature has distinguished in the most unambiguous manner. The instincts of brutes are in general, stronger, and less subject to restraint, than those of man. The reason is plain: They have not an equal number of instincts to curb, counterbalance, or moderate their motives to particular actions. Hence they have often the appearance of acting by mere impulse; and this circumstance has led
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some philosophers to consider brutes as machines. But they reflect not that children, savages, and ignorant men, act nearly in the same manner. It is society and culture which soften and moderate the passions and actions of men, as well as those of docile animals.

Brutes, like men, learn to see objects in their proper position, to judge of distances and heights, and of hurtful, pleasurable, or indifferent bodies. Without some portion of reason, therefore, they could never acquire the faculty of making a proper use of their senses. A dog, though pressed with hunger, will not seize a piece of meat in presence of his master, unless it be given to him: But with his eyes, his movements, and his voice, he makes the most humble and expressive petition. If this balancing of motives be not reasoning, I know not by what other name it can be called,

Animals, recently after birth, know not how to avoid danger. Neither can they make a proper use of their members. But experience soon teaches them what is pleasant and what is painful, what objects are hurtful and what salutary. A young cat, or a dog, who has had no experience of leaping from a height, will, without hesitation, precipitate

cipitate itself from the top of a high wall. But, after perceiving that certain heights are hurtful, and others innooffensive, the animal learns to make the distinction, and never afterwards can be prevailed upon to leap from a height which it knows will be productive of pain.

Young animals examine every object they meet with. In this investigation they employ all their organs. The first periods of their life are dedicated to study. When they run about, and make frolicksome gambols, it is Nature sporting with them for their instruction. In this manner they improve their faculties and organs, and acquire an intimate knowledge of the objects which surround them. Men who, from peculiar circumstances, have been prevented from mingling with companions, and engaging in the different amusements and exercises of youth, are always awkward in their movements, cannot use their organs with ease or dexterity, and often continue, during life, ignorant of the most common objects.

From the above facts and reasoning, it seems to be apparent, that instincts are original qualities of mind; that every animal is possessed of some of these qualities; that
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the intelligence and resources of animals are proportioned to the number of instincts with which their minds are endowed; that all animals are, in some measure, rational beings; and that the dignity and superiority of the human intellect are necessary results, not of the conformation of our bodies, but of the great variety of instincts which Nature has been pleased to confer on the species.

CHAPTER VI.

Of the Senses.

NO animal of which we have any knowledge is endowed with more than the five external senses of smelling, tasting, hearing, touch, and seeing; and no animal, however imperfect, is destitute of the whole. Without organs of sensation, in a smaller or greater number, animal or intellectual existence is to us an inconceivable idea. Hence the notion of the ancients, and of a very few moderns, that this earth as well as all the heavenly bodies, are intelligent beings, though they have not the vestige of any instrument of sensation, or of any thing analogous to our ideas of animation, except mechanical motion, is too absurd even to be seriously mentioned.

Upon this interesting subject, as it comprehends every source of information, and every motive to action in man, as well as in the inferior animals, it is not surprising that so much has been written, and that so many different theories have been invented,
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and submitted to public inspection. Some of these theories shall be taken notice of in a cursory manner, and others, as unworthy of attention, shall be passed over in silence.

Our observations on the different instruments of sensation shall proceed in the following order, namely, of the senses of smelling, of tasting, of hearing, of touch, and of seeing. In general, it may be remarked, that all sensation is conveyed to the mind by an unknown influence of the nerves. If the optic, olfactory, or any nerve distributed over an organ of sensation, be cut, or rendered paralytic, the animal instantly loses that particular sense. This is a fact universally established by experiment. But that the nerves, which are perfectly similar in every part of the body, should, when distributed over the eye, the ear, the tongue, the nose, convey to the mind feelings so different, is the most mysterious part of this subject. When M. de Bonnet tells us, that every organ of sense probably consists of fibres specifically different; and that these fibres are particular senses endowed with a peculiar manner of acting, corresponding to the perceptions they excite in the mind;—he means to reason; but he does

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different theories have been
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no more than give a circumlocution for the fact.

OF SMELLING.

IN man, and many other animals, the organ by which the sense of smelling is conveyed to the mind, has received the general appellation of *nose*, or *nostrils*. The more immediate instrument of this sensation is a soft, vascular, porous membrane, covered with numerous papillae, and is known by the name of *membrana pituitaria*, or *membrana Schneideriana*. This membrane is totally covered with infinite ramifications and convolutions of the olfactory nerves. These nerves are almost naked, and exposed to the action of the air which passes through the nose in performing the function of respiration. But Nature, ever attentive to the ease and convenience of her creatures, has furnished the nostrils with a number of glands, or small arteries, which secrete a thick insipid mucus. By this mucus, the olfactory nerves are defended from the action of the air, and from the painful stimuli of acrid odours.

The odours perceived by smelling are extremely various. Some of them convey to us the most delightful and refreshing sensations,

tions, and others are painful, noxious, and disgusting. All bodies in Nature, whether solid or fluid, whether animated or inanimated, continually send forth to the air certain ~~effluvia~~ or emanations from their respective substances. These effluvia float in the atmosphere, and act upon the olfactory nerves of different animals, and sometimes of different individuals of the same species, in such a manner as to produce very different sensations. What is pleasant to the nostrils of one animal is highly offensive to those of another. Brute animals select their food chiefly by employing the sense of smelling, and it seldom deceives them. They easily distinguish noxious from salutary food; and they carefully avoid the one, and use the other for nourishment. The same thing happens with regard to the drink of animals. A cow, when it can be obtained, always repairs to the clearest and freshest streams; but a horse, from some instinctive impulse, uniformly raises the mud with his feet, and renders the water impure, before he drinks.

In the selection of food, men are greatly assisted, even in the most luxurious state of society, by the sense of smelling. By smelling we often reject food as noxious, and will
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not risk the other test of tasting. Victuals which have a putrid smell, are equally offensive to our nostrils as hurtful to our constitutions, we avoid with abhorrence; but we are equally allured to eat substances which have a grateful and savoury odour. The more frequent and more acute discernment of brutes in the exercise of this sense, is entirely owing to their freedom, and to their using natural productions alone. But men in society, by the arts of cookery, by the unnatural assemblage of twenty ingredients in one dish, blunt, corrupt, and deceive both their senses of smelling and of tasting. Were we in the same natural condition as the brutes, our sense of smelling would enable us to distinguish, with equal certainty, noxious from salutary food. Brutes, as well as men, prefer particular foods to others. This may be considered as a species of luxury; but it should likewise be considered, that all the articles they use are either animal or vegetable substances in a natural state, neither converted into a thousand forms and qualities by the operation of fire and water, nor having their flavour exalted by stimulating condiments. Domestic animals are nearly in the same condition with luxurious men. A pampered dog

snuffs and rejects many kinds of food, which, in a natural state, he would devour with eagerness.

It is not unworthy of remark, that, in all animals, the organs of smelling and of tasting are uniformly situated very near each other. Here the intention of Nature is evident. The vicinity of these two senses forms a double guard in the selection of food. Were they placed in distant parts of the body, they could not so readily give mutual aid to one another.

But assistance in the choice of food is not the only advantage that men and other animals derive from the sense of smelling. Every body in nature, whether animal, vegetable, or mineral, when exposed to the air, continually sends forth emanations, or effluvia, of such extreme subtilty, that no eye can perceive them. These effluvia, or volatile particles, diffuse themselves through the air, and most of them are recognised, by the organ of smelling, to be either agreeable or disagreeable. To give some idea of the inconceivable minuteness of these particles, and of the amazing sensibility of the nostrils of animals, the odour of musk has been known to fill a large space for several years without losing
any

any perceptible part of its weight. Thus, the air we breathe is perpetually impregnated with an infinity of different particles which stimulate the olfactory nerves, and give rise to the sensation of smell. When our senses are not vitiated by unnatural habits, they are not only faithful monitors of danger, but convey to us the most exquisite pleasures. Even the sense of smelling is always productive either of pleasure or pain. The fragrance of a rose, and of many other flowers, is not only pleasant, but gives a refreshing and delightful stimulus to the whole system, and may be considered as a species of wholesome nourishment; while the odours proceeding from hemlock, and from many other noxious vegetable, animal, and mineral substances, are highly offensive to our nostrils. Hence we are naturally compelled to embrace the one class of sensations and to avoid the other.

Some animals, as the dog, the fox, the raven, &c. are endowed with a most exquisite sense of smelling. A dog scents various kinds of game at considerable distances; and, if the fact were not confirmed by daily experience, it could hardly gain credit, that he can trace the odour of his master's foot through all the winding streets of a populous city. If we

judge from our own feelings, this extreme sensibility in the nose of a dog is to us perfectly incomprehensible.

The sense of smelling, like that of some other senses, may be perverted or corrupted by habit. The snuffing, chewing, and smoking tobacco, though at first disagreeable, become, by the power of habit, not only pleasant, but almost indispensable. The same remark is applicable to the practice of swallowing ardent spirits, the most deleterious of all poisons, because the most extensively employed. How the natural state of the nerves, and of the sensations conveyed by them, should be so completely changed, we are totally ignorant. The constitution of the nerves often varies in different individuals of the same species. An odour which is disgusting to one man is highly grateful to another. I knew a gentleman who was in the daily habit of lighting and putting out candles, that he might enjoy the pleasure of their smell. Few men, I suppose, would envy him.

OF T A S T I N G.

THE tongue and palate are the great instruments of this sensation. With much wisdom and propriety the organ of taste is situated

ated in such a manner as enables it to be a guardian to the alimentary canal, and to assist the organ of smell in distinguishing salutary from noxious food. The tongue, like the other instruments of sensation, is amply supplied with nerves. The terminations of these nerves appear on the surface of the tongue in the form of *papillae*, or minute nipples, which are always erected on the application of sapid or stimulating substances. This elevation and extension of the papillae, by bringing larger portions of the nerves into contact with the substances applied to the tongue, give additional strength to the sensation, and enable us to judge with greater accuracy concerning their nature and qualities. Beside the nervous papillae, the tongue is perpetually moistened with saliva, a liquor which, though insipid itself, is one great cause of all tastes. The saliva of animals is a very powerful solvent. Every substance applied to the tongue is partially dissolved by the saliva before the sensation of taste is excited. When the tongue is rendered dry by disease, or any other cause, the sense of taste is either vitiated or totally annihilated.

In some men, the sense of taste is so blunt, that they cannot distinguish with any degree
of

of accuracy the different species of that sensation. In others, whether from Nature or from habit, this sense is so acute, that they can perceive the nicest distinctions in the favour of solids and of liquids.

The sensations conveyed to the mind by taste, like those of all the senses, are either agreeable, disagreeable, or indifferent. The pleasures arising from this sense are not only great, but highly useful to every animal. The sense itself, however, is comparatively gross; for, in smelling, hearing, and seeing, sensations are excited by emanations or undulations proceeding from bodies at great distances from the animals who perceive them. But, in tasting, the object must be brought into actual contact with the tongue before its qualities can be discovered. How this proportionally gross sense should have been selected, and figuratively applied to the general perception of every thing beautiful and sublime, whether in Nature or in art, it is difficult to determine. The inquiry, however, would not be incurious, whether men who have an obtuse sense of tasting material substances are likewise deficient in the perception of beauty and deformity.

Though

Though the sense of taste varies in some individuals, yet, like figurative taste, the standard of agreeable and disagreeable, of pleasant and painful, is almost universally diffused over mankind and the brute creation. Every horse, and every ox, when in a natural state, eat and reject, the same species of food. But men in society, as well as domestic animals, are induced by habit, by necessity, or by imitation, to acquire a taste for many dishes, and combinations of substances, which, before the natural discriminating sense is perverted, would be rejected with disgust.

Some individuals of the human species have an aversion to particular kinds of food, which are generally agreeable. This aversion may be either original or acquired. I knew a child, who, from the moment he was weaned, could never be induced to take milk of any kind. These original aversions must be ascribed to some peculiar modifications in the structure of the organ, or in the disposition of its nerves. But, in general, disgust at particular foods is produced by surfeits, which injure the stomach, and create, in that exquisitely irritable viscus, an insuperable antipathy to receive nourishment which formerly gave it so much uneasiness to digest.

Brute

Brute animals, especially those which feed upon herbage, and are not liable to be corrupted by example or necessity, distinguish tastes with wonderful accuracy. By the application of the tongue, they instantly perceive whether any plant is salutary or noxious. To enable them, amidst a thousand plants, to make this discrimination, their nervous papillae, and their tongues, are proportionally much larger than those of man.

OF HEARING.

THE sensation of hearing is conveyed to the mind by undulations of air striking the ear, an organ of a very delicate and complex structure. In man and quadrupeds, the external ears are large, and provided with muscles by which they can erect and move them from side to side, in order to catch the undulations produced in the air by the vibrations of sonorous bodies, or to distinguish with greater accuracy the species of sound, and the nature and situation of the animal or object from which it proceeds. Though the human ears, like those of quadrupeds, are furnished with muscles, evidently intended for similar movements, yet, I know not for what reason, there is not one man in a million who has
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the power of moving his ears. When we listen to a feeble sound, we are conscious of an exertion; but that exertion, and the motions produced by it, are confined to the internal parts of the organ.

The canals or passages to the internal parts of the ear are cylindrical, somewhat contorted, and become gradually smaller till they reach the *membrana tympani*, which covers what is called the drum of the ear. This membrane, which is extremely sensible, when acted upon by undulations of air, however excited, conveys, by means of a complex apparatus of bones, nerves, &c. the sensation of sound to the brain or sentient principle.

That air is the medium by which all sounds are propagated, has been established by repeated experiments. The sound of a bell, suspended in the receiver of an air-pump, gradually diminishes as the air is exhausted, till it almost entirely ceases to be heard. On the other hand, when the quantity of air is increased by a condenser, the intensity of the sound is proportionally augmented. Mr. Hauksbee, in a paper published in the Philosophical Transactions, has proved, that sounds actually produced cannot be transmitted through a *vacuum*, or a space deprived of air.

‘I took,’

‘I took,’ says he, ‘a strong receiver, armed
‘with a brass hoop at the bottom, in which
‘I included a bell as large as it could well
‘contain. This receiver I screwed strongly
‘down to a brass plate with a wet leather be-
‘tween, and it was full of common air, which
‘could nowise make its escape. Thus secur-
‘ed, it was set on the pump, where it was
‘covered with another large receiver. In
‘this manner, the air contained between the
‘outward and the inward receivers was ex-
‘hausted. Now here I was sure, when the
‘clapper should be made to strike the bell,
‘there would be actually sound produced in
‘the inward receiver; the air in which was
‘of the same density as common air, could
‘suffer no alteration by the *vacuum* on its
‘outside, so strongly was it secured on all
‘parts. Thus, all being ready for trial, the
‘clapper was made to strike the bell; but I
‘found that there was no transmission of it
‘through the *vacuum*, though I was sure there
‘was actual sound produced in the inward
‘receiver.’

To enable us to understand the manner in
which sounds are propagated through the
air, philosophers have had recourse to the
undulations produced by a stone thrown into
a pond

a pond of stagnating water. These undulations assume the form of circular waves, which successively proceed from the place where the stone struck the water, as from a center, and continually dilate, and become greater and greater as they recede from that center, till they reach the banks of the water, where they either vanish or are reflected. Now, as air is likewise a fluid, similar undulations, though to us invisible, are produced in it by the vibrations of sonorous bodies, and are also propagated to great distances in successive waves or rings. These undulations of the air, when they come into contact with our organs of hearing, make such a tremulous impression upon them as excites in our minds the sensation of sound. This analogy, though not altogether perfect, is sufficient to illustrate those invisible motions of the air by which sounds are conveyed from one place to another, and to give an idea of echoes, or reflected undulations of that fluid.

The celerity with which sounds, or undulations of air, move, has been exactly computed. All sounds, whether acute or grave, strong or weak, move at the rate of 1142 feet in a second of time. Hence, whenever the lightning of thunder, or the fire of artillery, are

are seen, their actual distances from the observer may be easily ascertained by the vibrations of a pendulum. This velocity, it is true, may be a little augmented or diminished by favourable or by contrary winds, and by heat or cold. But the difference, even in high winds, is so trifling, that, for any useful purpose, it scarcely merits attention.

Infants hear bluntly, because the bones of their ears are soft and cartilaginous; and, of course, the tremulations excited in them by the motions of the air are comparatively weak. Young children, accordingly, are extremely fond of noise. It rouses their attention, and conveys to them the agreeable sensation of sound; but feeble sounds are not perceived, which gives infants, like deaf persons, the appearance of inattention, or rather of stupidity.

The force or intensity of sound is augmented by reflection from surrounding bodies. It is from this cause that the human voice, or any other noise, is always weaker, and less distinctly heard in the open air than in a house.

The modifications of sound are not less various than those of tastes or odours. The ear is capable of distinguishing some hundred
tones

tones in sound, and probably as many degrees of strength in the same tones. By combining these, many thousand simple sounds, which differ either in tone or in strength, are perceived and distinguished by the ear. A violin, a flute, a French-horn, may each of them give the same tone; but the ear easily makes the distinction. The immense variety of sensations, arising from the organs of smelling, of tasting, and of hearing, enables animals to judge concerning the nature and situation of external objects. By habit we learn to know the bodies from which particular species of sounds proceed. Previous to all experience, we could not distinguish whether a sound came from the right or the left, from above or below, from a greater or a smaller distance, or whether it was the sound of a coach, of a drum, of a bell, or of an animal. By catching cold, I once had a temporary deafness in my left ear. I was surprised to find that I had lost the faculty of perceiving the situation from which sounds proceeded. If a dog barked on the left, I thought the noise came from the right. This circumstance excited my curiosity: But, upon recollection, I knew that my left ear was deaf; and that every sound I heard was perceived solely

solely by the right; and, consequently, I discovered the cause of the deception.

Hearing enables us to perceive all the agreeable sensations conveyed to our minds by the melody and harmony of sounds. This, to a man at least, is a great source of pleasure and of innocent amusement. But some men are almost totally destitute of the faculty of distinguishing musical sounds, and of perceiving those delightful and diversified feelings excited by the various combinations of musical tones. Most men derive pleasure from particular species of music. But a musical ear, in a restricted, sense, is by no means a general qualification. An ear for music, however, though not to be acquired by study, when the faculty itself is wanting, may be highly improved by habit and culture. Buffon, after examining a number of persons who had no ear for music, says, that every one of them heard worse in one ear than in the other; and ascribes their inability of distinguishing musical expression to that defect. But a musical ear seems to have no dependence on acuteness or bluntness of hearing, whether in one or in both ears. There are many examples of people who may be said to be half deaf, and yet are both fond of music,

fic, and skilful practitioners. An ear for music, like a genius for painting or poetry, is a gift of Nature, and is born with the possessor.

Beside the innumerable pleasures we derive from music and agreeable sounds, the extension and improvement of *artificial* language must be considered as objects of the greatest importance to the human race. Without the sense of hearing, mankind would forever have remained mute. I mention *artificial*, or improved language, because, from a thousand observations which every person must have made, it is perfectly apparent, that, if destitute of a *natural* language, neither man nor the brute creation* could possibly have existed and continued their species. As brutes, without information or experience, are capable of communicating to each other, by particular sounds and gestures, their pleasures and pains, their wants and desires, it would be the highest absurdity to suppose that the great Creator should have denied to man, the noblest animal that inhabits this globe, the same indispensable privilege. Without a basis there can be no fabric. Without a *natural* no

* Concerning the language of beasts, I shall, perhaps, be more explicit in a future work.

artificial

artificial language could possibly have existed. This point is clearly demonstrated, in a few words, by that most ingenious, candid, and profound philosopher, Dr. Thomas Reid, Professor of Moral Philosophy in the University of Glasgow. ‘If mankind,’ says Dr. Reid, ‘had not a *natural* language, they could never have invented an artificial one by their reason and ingenuity. For all artificial language supposes some compact or agreement to affix a certain meaning to certain signs; therefore, there must be compacts or agreements before the use of artificial signs; but there can be no compact or agreement without signs, nor without language; and therefore there must be a natural language before any artificial language can be invented*.’ Let any man try to overturn this argument, which is founded, not upon *metaphysical* conjecture, but upon the solid basis of *fact* and uncontrovertible *reasoning*. The elements, or constituent parts of the natural language of mankind, the Doctor reduces to three kinds; modulations of the voice, gestures, and features. ‘By means of these,’ says he, ‘two savages, who have no common

* Doctor Reid’s Inquiry into the Human Mind, on the Principles of Common Sense, pag. 93.

‘ artificial language, can converse together;
 ‘ can communicate their thoughts in some
 ‘ tolerable manner; can ask and refuse, af-
 ‘ firm and deny, threaten and supplicate;
 ‘ can traffic, enter into covenants, and plight
 ‘ their faith.’

I can perceive only one plausible objection to this reasoning. If it may be said, man were endowed with a natural language, this language must be universal; from what source, then, can the great diversity of languages in different nations, and tribes of the human race, be derived? The solution of this question depends not upon metaphysical arguments, but upon fact and experience. I have had considerable opportunities of observing the behaviour of children. Infants when very young, have nearly the same modes of expressing their pleasures and pains, their desires and aversions. These they communicate by voice, gesture, and feature; and every infant, whatever be the country, climate, or language, uniformly expresses its feelings almost in the same manner. But when they arrive at nine or twelve months of age, a different scene is exhibited. They then, beside the general expressions of feeling and desire, attempt to give names to particular

objects. Here artifice begins. In their attempts, previous to the capacity of imitating articulate sounds, every individual infant utters different sounds, or rather gives different names, to signify the same objects of its desire or aversion. Beside this natural attempt towards a nomenclature, infants, during the period above mentioned, (for the time varies according to the health and vivacity of the child), frequently make continued orations. These orations consist both of articulate and inarticulate sounds, of which no man can give an idea in writing. But most men, and every woman who has nursed children, will perfectly understand what I cannot express. From the fact, that children actually utter different sounds, or give different names to denote the same objects, I imagine, arises all that diversity of languages, which, by exhausting time and attention, retard the progress and improvement both of Art and Science. If any number of children, or of solitary savages, should chance to associate, the names of objects would soon be settled by imitation and consent. By observation and experience the number of names would be augmented, as well as the qualities or attributes of the objects themselves; and, in the progress of
time,

time, a new and artificial language would be gradually formed. While this operation is going on in one corner of a country, twenty similar affociations and compacts may be forming, or already formed, in different nations, or in different districts of the same nation, all of which would give birth to separate artificial languages.

OF TOUCH.

THE sensations of smelling, tasting, hearing, and seeing, are conveyed to us by partial organs, which are all confined to the head. But the sense of touching, or of feeling, is not only common to these organs but extends over almost every part of the body, whether external or internal. Though every sensation may be comprehended under the general appellation of *feeling*, yet what is called the sense of *touch* is properly restricted to the different sensations excited by bodies applied to the skin, and particularly to the tips of the fingers.

With regard to sensation in general, it is worthy of remark, that the eyes, the ears, the nostrils, the tongue and palate, the palms of the hands, especially towards the points of the fingers, are more amply supplied with

nerves than any other external parts of the body. The terminations of the nerves on the surface of the skin are soft and pulpy, and form minute protuberances resembling the nap of freeze-cloth, though greatly inferior in magnitude. These protuberances have received the denomination of *nervous papillae*. They might be called *animal feelers*; for they are obviously the immediate instruments of sensation. If an object be presented to the eye, or any other organ of sensation, certain feelings are excited, which are either agreeable or disagreeable, according to the real or imaginary qualities which we consider as belonging to that object. The feelings thus excited instantly produce a change in the sensitive organs by which they are occasioned. If the object be possessed of disagreeable qualities, aversion is the necessary consequence. But, if beauty and utility are perceived in the object, pleasant emotions spring up in the mind, which naturally induce a similar tone or disposition in the organs suited for the enjoyment of these qualities.

When examining or enjoying any object, it is natural to inquire what are the changes produced in the nervous papillae, or organs of sensation? If an object possessed of agreeable

able feelings is perceived, the nervous papillae instantly extend themselves, and from a state of flaccidity, become comparatively rigid like bristles. This extension of the papillae is not conjectural: It is founded on anatomical observation, and, in some cases, may be seen and felt by persons of acute and discerning sensations. When a man in the dark inclines to examine any substance, in order to discover its figure, or other qualities, he perceives a kind of rigidity at the tips of his fingers. If the fingers are kept long in this state the rigidity of the nervous papillae will give him a kind of pain or anxiety, which it is impossible to describe. The cause of this pain is an over-distension of the papillae. If a small insect creeps a man's hand, when the papillae are flaccid, its movements are not perceived: But, if he happens to direct his eye to the animal, he immediately extends his papillae, and feels distinctly all its motions. If a body be present, which, in the common state of the nerves, has scarcely any sensible odour, by extending the papillae of the nostrils, an agreeable, disagreeable, or indifferent smell will be perceived. When two persons are whispering, and we wish to know what is said, we stretch the papillae, and the other organs of hearing, which are exceedingly complex. If a
 found

found is too low for making an impression on the papillae in their natural state of relaxation, we are apt to overstretch the organ, which produces a painful, or irksome feeling. When we examine a mite, or any very minute object, by the naked eye, a pain is propagated over every part of that organ. Several causes may concur in producing this pain, such as the dilating of the pupil, and the adjusting the crystalline lens; but the chief cause must be ascribed to the preternatural intumescence and extension of the papillae of the retina, the substance of which is a mere congeries of nervous terminations. This circumstance confirms a former remark, that the immediate organs of sensation were more copiously supplied with nervous papillae than those parts whose uses require not such exquisite sensibility; for a distinction in this respect is observable even among the sensitive organs themselves. They are furnished with nerves exactly proportioned to the subtilty of the objects whose impressions they are fitted to receive. The eye possesses by far the greatest number. The particles of light are so minute, that, had not this wise provision been observed in the construction of the eye, it could never have been able to distinguish

distinguish objects with such accuracy as at present it is capable of performing. When an insipid body, or a body which conveys but a very feeble sensation of taste, is applied to the tongue, we are conscious of an effort which that organ makes in order to discover the quality of the body thus applied. This effort is nothing but the stretching of the nervous papillae, that they may enlarge the field of contact with the body under examination.

The pleasure or pain produced by the sense of touch depends chiefly on the friction, or number of impulses, made upon the papillae. Embrace any agreeable body with your hand, and allow it to remain perfectly at rest, and you will find the pleasure not half so exquisite as when the hand is gently moved backward and forward upon the surface. Apply the hand to a piece of velvet, and it is merely agreeable: Rub the hand repeatedly on the surface of the cloth, and the pleasant feeling will be augmented in proportion to the number of impulses on the papillae. When a man is pinched with hunger, the sight or idea of palatable food raises the whole papillae of his tongue and stomach. From this circumstance he is highly regaled by eating.

But,

But, if he eats the same species of food when his stomach is less keen, the pleasure in the one case is not to be compared with what is felt in the other. The cause is obvious: His desire was not so urgent; the object, of course, was less alluring; and therefore he was more remiss in erecting his papillae, or in putting them in a tone suited to such eminent gratification.

The same observations are applicable to disagreeable or painful objects of contact. If the hand is laid upon a gritty stone, or a piece of rusty iron, the feeling is disagreeable; but if it is frequently rubbed upon the surface of these bodies, the feeling becomes insufferably irksome.

It is by the sense of touch that men, and other animals, are enabled to perceive and determine many qualities of external bodies. By this sense we acquire the ideas of hardness and softness, of roughness and smoothness, of heat and cold, of pressure and weight, of figure, and of distance. The sense of touch is more uniform, and liable to fewer deceptions, than those of smelling, tasting, hearing, and seeing; because in examining the qualities of objects, the bodies themselves must be brought into actual contact with the
organ,

organ, without the intervention of any medium, the variations of which might mislead the judgment.

OF SEEING.

OF all the senses that of seeing is unquestionably the noblest, the most refined, and the most extensive. The ear informs us of the existence of objects at comparatively small distances; and its information is often imperfect and fallacious. But the organ of sight, which is most admirably constructed, not only enables us to perceive thousands of objects at one glance, together with their various figures, colours, and apparent positions, but, even when unarmed, to form ideas of the sun and planets, and of many of the fixed stars; and thus connects us with bodies so remote, that imagination is lost when it attempts to form a conception of their immense magnitude and distances. This natural field of vision, however great, has been vastly extended by the invention of optical instruments. When aided by the telescope, the eye penetrates into regions of space, and perceives stars innumerable, which, without the assistance of art, would to us have no existence. Our ideas of the beauty, magnitude, and remoteness

moteness or vicinity of external objects, are chiefly derived from this delicate and acute instrument of sensation.

Before proceeding to the peculiarities of vision, and the general properties of light, we shall give a short description of the structure of the eye.

The globe of the eye is composed of three humours, called *aqueous*, *crystalline*, and *vitreous*; and of the *retina*, *ciliary ligament*, and *iris*. All these are contained within the *sclerotica* and *cornea*, or capsule of the eye. The white part of the cornea is opaque; but the *pupil*, or *sight* of the eye, through which the rays of light pass, is transparent. The *aqueous humour* is *ameniscus*, or a convex exteriorly, and concave internally. The *crystalline humour* is doubly convex; and its exterior convexity is embraced by the concave surface of the aqueous. The *vitreous* humour is likewise a meniscus; its concave surface embraces the interior convexity of the crystalline, and its convex surface is encompassed by the *retina*, which is a fine expansion of the medullary fibres of the optic nerve spread upon the convex surface of the vitreous humour, and covering the bottom of the eye. The *ciliary ligament* is a ring of fibres, which in-
close

close the edges of the crystalline, and stretch in right lines towards its center. When these fibres contract, the distance between the retina and crystalline is lengthened; and that distance is shortened when these fibres are in a relaxed state. The *iris* is that coloured circle which furrounds the pupil.

By this curious apparatus all the phaenomena of vision are conveyed to the mind. But, before we enter upon the manner in which the different parts of the eye concur in transmitting the rays of light and the images of objects to the retina, it will be necessary to give some general ideas concerning the nature of light, which is the universal medium of vision.

Light consists of innumerable rays, which proceed in direct lines from every part of luminous bodies. The motion of light, though not instantaneous, is inconceivably swift. To give some comparative idea of its great velocity, it has been discovered by philosophers, that rays of light coming from the sun reach this earth in seven minutes. Now, the distance of the earth from the sun is so immense, that, supposing a cannon ball to move at the rate of 500 feet in a second, it could not come from the sun to the earth in less
than

than 25 years. At this rate, the velocity of light will be above 10 million of times greater than that of a cannon ball.

The rays of light, though they proceed in direct lines from luminous bodies, are refracted, or bent out of their course, in passing through different mediums, as the air, glass, and every transparent substances; but, when they fall upon opaque bodies, they are reflected. Rays proceeding from any object, and passing through a convex glass or lens, are refracted and collected into a point, or small space, at a certain distance from the glass, which is called the *focus* of that lens.

The white light conveyed to us by the sun is not homogeneous, but consists of seven differently coloured rays, or what are called the *primary colours*. These differently coloured rays were discovered by Sir Isaac Newton to have different degrees of refrangibility. When the white light of the sun was made to pass through a glass prism, he found, that, instead of retaining its original whiteness, it exhibited seven distinct colours, and that this phaenomenon was produced by the several rays in the composition of white light being more or less refracted, or turned from their direct course. The simple primary colours
are

are seven in number, namely, red, orange, yellow, green, blue, indigo, and violet. Red is the least, and violet the most refrangible parts of white light. A proper mixture of all the seven primary colours constitutes whiteness; and by various combinations of the primary colours, all the compound colours exhibited either in Nature or art are produced. Any surface appears black when it reflects little or no light.

The different humours of the eye, and the crystalline lens, are all denser than the air or water; of course, their power of refracting the rays of light is likewise greater. The rays proceeding from every point of an object enter the pupil; and the refraction of the different parts of the eye, which act as a lens, necessarily makes them cross each other in their passage to the retina. After crossing, they diverge till they are stopped by the retina, where they form an inverted picture. The upper part of the object is painted on the lower part of the retina, and the right side upon the left, &c. The celebrated Kepler first discovered, that distinct, but inverted pictures of every object we behold are painted on the retina by the rays of light proceeding from visible objects. This discovery naturally

turally led Kepler, as well as many other philosophers since his time, to inquire how we should see objects erect from inverted images on the retina.

Many ingenious theories have been invented, and many volumes have been written, in order to explain this seemingly difficult question. To give even a cursory view of these theories would not only be tedious, but in a great measure useless. We shall therefore only remark, that their authors uniformly assumed it as a principle, that, because the pictures are inverted on the retina, the mind ought also to perceive them in the same position. It is certain, that, unless distinct images are painted on the retina, objects cannot be clearly perceived. If, from too little light, remoteness, or any other cause, a picture is indistinctly painted on the retina, an obscure or indistinct idea of the object is conveyed to the mind. The picture on the retina, therefore, is so far the cause of vision, that unless this picture be clear and well defined, our ideas of the figure, colour, and other qualities of any object presented to the eye, will be obscure and imperfect. The retina of the eye resembles a canvas on which objects are painted. The colours of these pictures are
bright

bright or obscure, in proportion to the distances of the objects represented. When objects are very remote, their pictures on the retina are so faint, that they are entirely obliterated by the vigorous and lively impressions of nearer objects, with which we are every way surrounded. On the other hand, when near objects emit a feeble light only, compared with that which proceeds from a remote object, as, for example, when we view luminous bodies in the night, then very distant objects make distinct pictures on the retina, and become perfectly visible. Hence a man, by placing himself in a dark situation, and looking through a long tube, without the intervention of a glass, may make a kind of telescope, which will have a considerable effect even during the day. For the same reason, a man at the bottom of a deep pit can see the stars at noon.

The first and greatest error in vision, in the opinion of many authors, arises from the inverted representation of objects upon the retina; and they maintain, that, till children learn the real position of bodies by the sense of feeling, they see every object inverted. But new born animals, whether of the human or brute species, see objects, not inverted, but
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in their real positions, independently of all experience, or of any opportunity of rectifying the supposed illusion by the sense of touch. Animals see objects in their real position by a law of Nature, and by the instrumentality of the eye and optic nerve. Were it not a law of Nature, or of the constitution of animals, to see objects erect, though their images be inverted on the retina, an inverted object could not possibly appear inverted; for, in this case, we should not be obliged to have recourse to experience, or to the sense of feeling. Besides, it is an established fact, that blind men, who had been restored to sight by surgical operations, instantly saw objects in their real position*. There is no relation to the principles of optics, in the sensation of feeling, by which an image, painted by rays of light on soft white nervous terminations, is conveyed through a most opaque body, in a long course of perfect darkness, to the brain. Indeed, the sense by which the perceiving nerves of any kind are affected, is not an image or idea of the object. The idea of redness has nothing in common with the least refrangible portions of light separated from the other six coloured rays of which white light

* Haller. *Physiol* tom. 2. pag. 87.

is composed. The pain of burning represents not to the mind any thing of that swift and subtle matter by which the nervous threads are broken or destroyed. There is nothing in the idea of a sharp sound, from a cord of a certain length, which can inform the mind that this cord vibrates 2000 times in a second †.

Another question with regard to vision has been much agitated by philosophers. Because a separate image of every object is painted on the retina of each eye, it was concluded, that we naturally see all objects double; that we learn to correct this error of vision by the sense of touching; and that, if the sense of seeing were not constantly rectified by that of touching, we should be perpetually deceived as to the position, number, and situation of objects. The Count de Buffon mentions the real fact, though he ascribes it to a wrong cause. ‘When two images,’ says he, ‘fall on
‘ *corresponding* parts of the retinae, or those
‘ parts which are always affected at the same
‘ time, objects appear single, because we are
‘ *accustomed* to judge of them in this manner.
‘ But, when the images of objects fall upon

* For a more ample discussion of this point, see Haller. Physiol. tom. 2.;—and Dr. Reid’s Inquiry.

‘ parts of the retinae which are not usually
‘ affected at the same time, they then appear
‘ double, because we have not acquired the
‘ *habit* of rectifying this unusual sensation.
‘ Mr. Cheffelden, in his anatomy, relates the
‘ case of a man who had been affected with
‘ a strabismus, or squinting, in consequence
‘ of a blow on the head. This man saw every
‘ object double for a long time: But he gradually
‘ learned to correct this error of vision,
‘ with regard to objects which were familiar
‘ to him; and, at last, he saw every object
‘ single as formerly, though the squinting was
‘ never removed. This is a proof still more
‘ direct, that we really see all objects double,
‘ and that it is by *habit* alone we learn to
‘ conceive them to be single *.

In this, and other passages, the Count de Buffon has pointed out the genuine cause (or ultimate fact) why we see objects single with two eyes. He tells us, that, though a distinct image is painted on each retina, whenever these images are painted on corresponding points of the retinae, an object is perceived to be single. It is equally true, that, when one eye is distorted by the finger, or any other cause, in such a manner that the images

* Buffon, vol. 3. pag. 7. Translat.

are painted on points of the retinae which do not correspond, the object is perceived to be double. Objects which are much nearer, or much more remote, than that to which both eyes are directed, appear double. If a candle is placed at the distance of ten feet, and a man holds his finger at arm's-length between his eyes and the candle, when he looks at the candle, he sees his finger double, and, when he looks at his finger, he sees the candle double. 'In this phaenomenon,' Dr. Reid properly remarks, 'it is evident to those who understand optics, that the pictures of objects which are seen double, do not fall upon points of the retinae which are similarly situated, but that the pictures of objects seen single do fall upon points similarly situated. Whence we infer, that as the points of the two retinae, which are similarly situated with regard to the centers, do correspond, so those which are dissimilarly situated do not correspond. It is to be observed, that although, in such cases as are mentioned in the last phaenomenon, we have been accustomed from infancy to see objects double which we know to be single; yet custom, and experience of the unity of

‘ the object, never take away this appearance
 ‘ of duplicity *.’

The sense of seeing, without the aid of experience, conveys no idea of distance. If not assisted by the sense of touching, all objects would seem to be in contact with the eye itself. Objects appear larger or smaller according as they approach or recede from the eye, or according to the angle they subtend. A fly, when very near the eye, seems to be larger than a horse or an ox at a distance. Children can have no idea of the relative magnitude of objects, because they have no notion of the different distances at which they are seen. It is only after measuring space by extending the hand, or by transporting their bodies from one place to another, that children acquire just ideas concerning the real distances and magnitudes of objects. Their ideas of magnitude result entirely from the angle formed by the extreme rays reflected from the superior and inferior parts of the object: Hence every near object must appear to be large, and every distant one small. But after, by touch, having acquired ideas of distances, the judgment concerning magnitude begins to be rectified. If we judge solely by

* Dr. Reid's Inquiry, &c. pag. 287.

the eye, and have not acquired the habit of considering the same objects to be equally large, though seen at different distances, the nearest of two men, though of equal size, would seem to be many times larger than the farthest. But we know that the last man is equally large with the first; and, therefore, we judge him to be of the same dimensions. Any distance ceases to be familiar to us, when the interval is vertical, instead of being horizontal; because all the experiments by which we usually rectify the errors of vision, with regard to distances, are made horizontally. We have not the habit of judging concerning the magnitude of objects which are much elevated above or sunk below us. This is the reason that, when viewing men from the top of a tower, or when looking up to a globe or a cock on the top of a steeple, we think these objects much smaller than when seen at equal distances in a horizontal direction. During the night, on account of the darkness, we have no proper idea of distance, and, of course, judge of the magnitude of objects solely by the largeness of the angle or image formed in the eye, which necessarily produces a variety of deceptions. When travelling in the night, we are liable to mistake a bush that is near to us for a tree
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at a distance, or a distant tree for a bush which is at hand. When benighted in a part of the country with which we are unacquainted, and, of course, unable to judge of the distance and figure of objects, we are every moment liable to all the deceptions of vision. This is the origin of that dread which some men feel in the dark, and of those ghosts and horrible figures which so many people positively assert they have seen in the night. Such figures are commonly said to exist in the imagination only; but they often have a real existence in the eye; for, when we have no other mode of recognising unknown objects but by the angle they form in the eye, their magnitude is uniformly augmented in proportion to their vicinity. If an object, at the distance of twenty or thirty paces, appears to be only a few feet high, its height, when viewed within two or three feet of the eye, will seem to be many fathoms. Objects, in this situation, must excite terror and astonishment in the spectator, till he approaches and recognises them by actual feeling; for the moment a man examines an object properly, the gigantic figure it assumed in the eye instantly vanishes, and its apparent magnitude is reduced to its real dimensions. But if, instead
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of approaching an object of this kind, the spectator flies from it, he retains the idea which the image of it formed in his eye, and he may affirm with truth, that he beheld an object terrible in its aspect, and enormous in its size. Hence the notion of spectres, and of horrible figures, is founded in nature, and depends not solely on imagination.

When we have no idea of the distance of objects by a previous knowledge of the space between them and the eye, we try to judge of their magnitudes by recognising their figures. But, when their figures are not distinguishable, we perceive those which are most brilliant in colour to be nearest, and those that are most obscure to be at the greatest distance. From this mode of judging many deceptions originate. When a number of objects are placed in a right line, as lamps in a long street, we cannot judge of their proximity or remoteness but by the different quantities of light they transmit to the eye. Of course, if the lamps nearest the eye happen to be more obscure than those which are more remote, the first will appear to be last, and the last first.

Before I dismiss this subject, I feel an irresistible desire of giving a short view of the Abbé de Condillac's *Traité des Sensations**; a most ingenious performance, which, I believe, is not very generally known in this country.

In an advertisement prefixed to this Treatise, the sagacious and learned Abbé desires his readers to abstract themselves from all their preconceived opinions, and to imagine the situation and feelings of a statue, limited, at first, to a single sense, and afterwards acquiring gradually the whole five.

I. *Sense of Smelling alone.*

A man, or a statue, who had no sense but that of smelling, could have no other ideas than those of odours. He would be the smell of a rose, a violet, or a jessamine, according as the effluvia of these objects acted upon his single organ of sensation. From agreeable or disagreeable smells he would acquire ideas of pleasure and pain. By means of agreeable and disagreeable smells frequently repeated, these sensations would remain in his memory, and produce desire and aversion. He can now compare the smell of a rose with that

* From the edition 1754, in two volumes 12mo.

of an hemlock. As soon as he compares, he judges of the relation between two ideas. In proportion as these comparisons or judgments are repeated, he acquires, by habit, a greater facility in making them. He can judge of different degrees of pleasure and pain. Hence, when he feels uneasy, he recalls pleasant sensations which are past, and wishes for their return. This is the origin of desire and want. Memory is the recollection only of what is past; but, when the ideas of objects present themselves in so lively a manner, that he believes they are actually present, this operation of the mind is called imagination. Being limited to the use of one sense, he would learn to distinguish smells with greater accuracy than beings endowed with more sources of information. Abstraction is the separation of two ideas which have a natural connection. By reflecting that the ideas of pain and pleasure result from different modifications of his existence, he contracts the habit of separating them, and thus acquires abstract notions. To our statue, a violet is a particular idea only; consequently, all his abstractions are limited to different degrees of pleasure and pain. The succession of sensations will give him
some

some faint ideas of number, of past, and of future time. Duration is an idea purely relative, and changes according to the rapidity or slowness of our perceptions. Our statue is incapable of distinguishing dreams, or a lively imagination, from real sensations. By the aid of memory he recognises his identity, and knows his present from his past condition. From these remarks it appears, that a man limited to one sense is capable of acquiring the rudiments of every human faculty, and that these faculties are only extended by the addition of other senses. Nearly the same acquisitions would be made, if a man were limited to any of the other senses.

2. *Of Hearing alone.*

The pleasures of the ear arise chiefly from the succession of sounds conformably to the rules of melody or of harmony. Hence our statue's desires would not be confined to a single sound; he would wish to become a complete air. Sounds produce greater emotions than odours. They excite joy or sadness independently of acquired ideas. Noise alone, without musical expression, would be agreeable: And music would convey pleasure proportioned to the exercise of the ear. Simple,

ple, and even coarse songs, would at first be ravishing. But, when gradually accustomed to music more compounded, the ear would discover new sources of delight. The pleasure of a succession of musical tones being superior to that of a continued noise, he would not confound the one with the other.

3. *Smelling and Hearing united.*

As these senses, taken separately, give to our statue no idea of external objects, neither can they by their union. He would never suspect that he had two different organs of perception, nor, at first, distinguish two modes of existence in himself. Sounds and odours would be confounded, and seem to be only one simple modification. He would learn, however, by experience, and the aid of memory, to distinguish two sensations; and then he would think that his existence was double. His train of ideas is more varied and extensive, because he has two kinds of modification; and, perhaps, noise would seem so different from harmonious sounds, that he might imagine he had three senses.

4. *Taste*

4. *Taste alone, and Taste united with Smelling and Hearing.*

When limited to taste alone, the statue would acquire the same mental powers as with smelling or hearing. Taste would contribute more to his happiness and misery than smelling or hearing; because flavours, in general, affect us more than smells, or even harmonious sounds.

When taste is united with smelling and hearing, the statue, after learning to know them separately, would be enabled to distinguish these sensations, even when transmitted to him at the same time; and therefore his existence would in some measure be triplicated. The union of these senses would still farther extend and diversify the train of his ideas, augment the number of his desires, and make him contract new habits.

5. *Of Sight alone.*

Sight and all sensations are internal, and belong to the mind. The difficulty is to conceive how we refer these sensations to external objects or causes. Our statue would consider light and colour as modes of his own existence; but could have no idea that they
be-

belonged to bodies distinct from himself. At first he would not be able to distinguish one colour from another; but he would soon acquire the habit of considering one colour at a time, and thus learn to distinguish them. By sight alone he could have no idea of figure, situation, extension, or motion.

6. *Sight united with Smell, Hearing, and Taste.*

This union would augment our statue's mode of existence, extend the chain of his ideas, and multiply the objects of his attention, of his desires, and of his enjoyments. But he would still continue to perceive himself alone, and could have no idea of external objects. He would see, smell, taste, and hear, without knowing that he had eyes, nose, mouth, or ears, nor even that he had a body. With the same colour before his eyes, if a succession of smells, favours, and sounds, were presented to him, he would consider himself as a colour successively odoriferous, savoury, and sonorous. If the same odour were constantly present with him, he would consider himself as a savoury, sonorous, and coloured odour.

7. *Of Touching alone.*

The smallest degree of sentiment, or feeling, which a man limited to the sense of touching could have, would arise from the action of different parts of the body, and particularly from the motion of respiration. This the Abbé calls the *fundamental sentiment*, because with it life commences. As soon as this fundamental sentiment has undergone any change, the statue is conscious of his own existence. When not struck by any external body, and placed in a temperate tranquil air, of an equal degree of heat, he would only recognise his existence by the confused impression resulting from the motion of respiration. He cannot distinguish the different parts of his body, and consequently has no idea of extension. Different feelings perceived at the same time convey a confused sensation only. But, when heat and cold are felt in succession, he distinguishes them, and retains in his memory the idea of each sensation. Touching different parts of his body, and of external objects, gradually unfolds the ideas of extension, solidity, softness, hardness, distance, &c. Hence he no longer confounds himself with his modifications. He is

no longer heat or cold; but he perceives heat in one part and cold in another. By means of the hand, he distinguishes his own person from external objects. When he touches the parts of his body, each part returns a sensation. But when he touches another body, he feels that it exists, but returns no sensation: and hence he learns that there are bodies which constitute no part of himself.

Children derive the greatest happiness from motion. Even falls do not deter them. A bandage on their eyes would give them less pain than a restraint on the use of their limbs. Motion, beside many other advantages, gives them the most lively consciousness of their own existence and powers. If exercise be pleasant to children, it would be still more so to our statue; for as yet he not only knows no obstacle to interrupt his movements, but he will soon experience all the pleasures to be derived from motion. The statue at first loves every body that does not hurt him. Polished and smooth surfaces will be agreeable to him; and he will be delighted to find that he can at pleasure enjoy warmth or coolness. He will receive peculiar pleasure from objects, which, from their figure and magnitude, are most accommodated to the form of
his

his hand. At other times, the difficulty of handling objects, on account of their size or weight, will give him pleasure by surprise; and this pleasure will be augmented by the space he discovers around them, which will render the motion of his body from one place to another extremely agreeable. Solidity and fluidity, hardness and softness, motion and rest, will be pleasant sensations; for the more he contrasts them, the more they will attract his attention and extend his ideas. But the habit he acquires of comparing and judging is the greatest source of his pleasures. He no longer touches objects solely for the pleasure of handling them. He wishes to know their relations, and he feels as many agreeable sensations as he forms new ideas.

Touching exposes him more frequently to pain than the other senses. But pleasure is always within his reach, and pain is felt only at intervals. His desires consist chiefly of the efforts of his mind to recal the most agreeable ideas. But that kind of desire of which the sense of touch renders him capable, includes motion, or the power of searching for sensations. Hence his enjoyments are not limited to the ideas presented by the imagination, but extend to all the objects he
can

can reach; and his desires, instead of being concentrated into modes of his existence, as in the other senses, lead him always to external bodies which are the objects of his love, hatred and other passions.

By motion he acquires the idea of space. Repeated experience of discovering new sensations renders him capable of curiosity. But pain represses his desire of moving, and makes him diffident. Hence he learns to move with caution; and the same chance that led him to lay hold of a stick, will teach him to use it for exploring what may be hurtful to him. Pleasure and pain are the sources of all his ideas, the number of which acquirable by our statue is almost infinite. He learns to compare his different sensations, and to distinguish different bodies. He acquires the idea of figure, and becomes capable of reflection and abstraction. He acquires likewise the ideas of number, of duration, of space, and of immensity.

8. *Of Touch united with Smelling.*

On this supposition, the statue would perceive himself to be two different beings, one that he could touch, and another which he could not. When chance made him lay hold

of an odorous body, he would find that its smell was stronger or weaker, in proportion as he brought the body nearer, or removed it farther from his face. This experiment frequently repeated will give him the idea that smell proceeds from, or is a quality of bodies. By the same means he discovers the organ of smelling. From this source his ideas concerning the qualities of bodies are greatly extended.

9. *Hearing, Taste, and Touching, united.*

At first our statue is totally occupied with this new sense, and believes himself to be the singing of birds, the noise of a cascade, &c. By the exercise, however, of handling sonorous bodies, or of letting them fall, he perceives that sound is produced by impulse or collision, gradually discovers this new organ, and that noise is a property of bodies even at a distance.

10. *Of Sight united with all the other Senses.*

The eye conveys no idea of distance, of magnitude, of figure, or of situation, without the assistance of touching. Either from chance, or from the pain occasioned by too strong light, the statue carries his hand to his
eyes.

eyes. The colours of objects instantly disappear. He moves his hand, and the colours return. Hence he learns that colours are not modes of his existence, but that they seem to be something existing in his eyes, in the same manner as he feels at the ends of his fingers the objects he touches.

The Abbé, in the same ingenious manner, shews how, by experience and habit, by motion and touching, we acquire a facility in correcting the errors of vision. But our limits permit us not to follow him any farther.

CHAPTER VII.

Of Infancy.

BY the term *infancy*, in this chapter, is generally meant that portion of life which commences at birth, and terminates at that period when animals have acquired the power of self preservation, without any assistance from their parents. This period varies greatly in different animals. Of course, when different species are mentioned, the term *infancy* must have very different limitations with regard to time.

The state of infancy, in the human species, continues longer than in any other animal. Infants, immediately after birth, are indeed extremely helpless, and require every assistance and attention from the mother. Most writers, however, on this subject seem to have exaggerated not only the imbecillity, but the miseries of the infant state. ‘An infant,’ says Buffon, ‘is *more helpless* than the young of any other animal: Its uncertain life seems every moment to vibrate on the borders of death. It can neither move nor
support

‘ support its body : It has hardly force enough
 ‘ to exist, and to announce, by groans, the
 ‘ pain which it suffers; as if Nature intend-
 ‘ ed to apprise the little innocent, that it is born
 ‘ to *miser*y, and that it is to be ranked among
 ‘ human creatures only to partake of their in-
 ‘ firmities and of their afflictions *.’

This humiliating picture is partly just, and partly misrepresented. Though infants remain longer in a state of imbecillity than the young of other animals, they are by no means more *helpless*. The infant after birth, they are capable of sucking whatever is presented to their mouths. When in the same condition, the young of the opossum, of hares, rabbits, rats, mice, &c. can do no more. They can neither move nor support their bodies. Besides, many quadrupeds are destitute of the sense of seeing for several days after birth. But the faculty of vision is enjoyed by infants the moment after they come into the world. This faculty, in a few hours, becomes a great source of pleasure and amusement to them; but it is denied, for some days, to many other species of animals. The young of most birds are equally weak and helpless as human infants. The former have
 no

* Buffon, vol. 2. pag. 369. Translat.

no other powers but those of respiration, opening their mouths to receive food from the parent, and ejecting the excrement, after the food has been properly digested. If infants really suffer more pain and misery than other animals in the same state, Nature seems not to merit that severity of censure which she has sometimes received. Man in society, like domestic animals, by luxury, by artificial modes of living, by unnatural and vicious habits, debilitate their bodies, and transmit to their progeny the seeds of weakness and disease, the effects of which are not felt by those who live more agreeably to the general oeconomy and intentions of Nature. The children of savages, for the same reason, whether in the hunting or shepherd state, are more robust, more healthy, and liable to fewer diseases, than those produced by men in the more enlightened and refined stages of society. Even under the same governments, and in the same state of civilization, a similar gradation of imbecillity and disease is to be observed. The children of men of rank and fortune are, in general, more puny, debilitated, and diseased, than those of the peasant or artificer. Still, however, children, in their progress from birth to maturity,
have

have innumerable sources of pleasure, which alleviate, if they do not fully compensate, the pain which must unavoidably be endured, whether in a more natural or more artificial state of mankind. If luxury and civilization debilitate the constitutions of children, they give rise to many real enjoyments which are totally unknown to the savage. His wants are fewer; but his gratifications are more than proportionally diminished.

Though the period of human infancy be proportionally long, it is too often increased by improper management. In this and many other countries of Europe, infants have no sooner escaped from the womb of their mothers, and have enjoyed the liberty of stretching their limbs, than they are again condemned to a more cruel and unnatural bondage. The head is fixed in one position; the legs are fettered; the arms are bound down to the sides; and the little innocents are laced with bandages so strait that they cannot move a single joint. The restraint of swaddling bands must be productive of pain. Their original intention was to prevent the head and limbs from being distorted by unnatural or hurtful positions. But it was not considered, that the efforts made by infants
to

to disentangle themselves, have a greater tendency to distort their members than any postures they could assume, if they enjoyed a greater degree of liberty. But, if the efforts for liberty made by infants fettered in this cruel manner be hurtful, the state of inactivity in which they are forced to remain, is, perhaps, equally noxious. Infants, as well as all young animals, are extremely prone to motion. It promotes the growth and expansion of their organs. It likewise invigorates all their members, and facilitates the circulation and secretion of their different fluids. But when infants are deprived of exercise, or of the power of performing their natural movements, the opposite effects are produced. The want of exercise retards their growth and weakens their constitution. Those children, therefore, who are allowed full freedom of motion will always be the most healthy and the most vigorous. We are, however, happy to remark, that, by the efforts of philosophers and physicians, the practice of employing tight bandages has of late become less general, especially among intelligent midwives and mothers. But, to eradicate long established prejudices, and to diffuse more enlightened and salutary notions
through

through a whole country, cannot be effected without a great length of time and vigorous exertions.

From what causes or circumstances particular modes in the management of infants originate, it is difficult to determine. But it is certain that savages, and the ruder nations, in their treatment of infants, often discover more discernment, and propriety of conduct, than are to be found in the most polished stages of society. The negroes, the savages of Canada, of Virginia, of Brasil, and the natives of almost the whole of South America, instead of using swaddling-bands lay their infants naked into hammocks, or hanging beds of cotton, or into cradles lined with fur. The Peruvians leave the arms of their infants perfectly loose in a kind of swathing-bag. When a little older, they are put, up to the middle, in a hole dug out of the earth, and lined with linen or cotton. * By this contrivance, their arms and head are perfectly free, and they can bend their bodies, and move their arms and head, without the smallest danger of falling, or of receiving any injury. To entice them to walk, whenever they are able to step, the breast is presented to them at a little distance. The children

children of negroes, when very young, cling round, with their knees and legs, one of their mother's haunches, and grasp the breast with their hands. In this position they adhere so firmly, that they support themselves without any assistance, and continue to suck without danger of falling, though the mother moves forward, or works at her usual labour. These children, at the end of the second month, begin to creep on their hands and knees; and, in this situation, they acquire, by habit, the faculty of running with surprising quickness.

Savages are remarkably attentive to the cleanliness of their children. Though they cannot afford to change their furs so frequently as we do our linen, this defect they supply by other substances of no value. The savages of North America put wood-dust, obtained from decayed trees, into the bottom of the cradle, and renew it as often as it is necessary. Upon this powder the children are laid, and covered with skins. This powder is very soft, and quickly absorbs moisture of every kind. The children in Virginia are placed naked upon a board covered with cotton, and furnished with a proper hole for transmitting the excrement. This practice is likewise almost general in the eastern

tern parts of Europe, and particularly in Turkey. It has another advantage: It prevents the dismal effects which too often proceed from the negligence of nurses.

Many northern nations plunge their infants, immediately after birth, into cold water, without receiving any injury. The Laplanders expose their new-born infants on the snow till they are almost dead with cold, and then throw them into a warm bath. During the first year, this seemingly harsh treatment is repeated three times every day. After that period, the children are bathed in cold water thrice every week. It is a general opinion in northern regions, that cold bathing renders men more healthy and robust; and hence they inure their children, from their very birth, to this habit. In the isthmus of America, the inhabitants, even when covered with sweat, plunge themselves with impunity into cold water. The mothers bathe in cold water, along with their infants, the moment after delivery; yet much fewer of them die of child-bearing, than in nations where a practice of this kind would be considered as extremely hazardous.

With regard to the food of infants, it should consist, for the first two months, of
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the mother's milk alone. A child may be injured by allowing it any other nourishment before the end of the first month. In Holland, in Italy, in Turkey, and over the whole Levant, children, during the first year, are not permitted to taste any other food. The Canadian savages nurse their children four or five years, and sometimes six or seven. In cases of necessity, the milk of quadrupeds may supply that of the mother. But, in such cases, the child should be obliged to suck the animal's teat; for the degree of heat is always uniform and proper, and the milk, by the action of the muscles, is mixed with the saliva, which is a great promoter of digestion. Several robust peasants have been known to have had no other nurses than ewes. After two or three months, children may be gradually accustomed to food somewhat more solid than milk. Before the teeth shoot through the gums, infants are incapable of mastication. During that period, therefore, it is obvious that Nature intended they should be nourished solely by soft substances. But, after they are furnished with teeth, it is equally obvious, that they should occasionally be allowed food of a more solid texture.

The

The bodies of infants, though extremely delicate, are less affected by cold than at any other period of life. This effect may be produced by the superior quickness in the pulsation of the heart and arteries which takes place in small animals. The pulse of an infant is more frequent than that of an adult. The pulse of a horse, or of an ox, is much slower than that of a man; and the motion of the heart, in very small animals, as that of a linnet, is so rapid that it is impossible to count the strokes.

The lives of children, during the first three or four years, are extremely precarious. After that period, their existence becomes gradually more certain. According to Simpson's tables of the degrees of mortality at different ages, it appears, that, of a certain number of infants brought forth at the same time, more than a fourth part of them died in the first year, more than a third in two years, and at least one half at the end of the third year. Mr. Simpson made this experiment upon children born in London. But the mortality of children is not nearly so great in every place; for M. Dupré de S. Maur, by a number of experiments made in France, has shown, that one half of the children

dren born at the same time are not extinct in less than seven or eight years.

To treat of the diseases of children, or to enter minutely into the causes which contribute to the great mortality of mankind in early infancy, is no part of our plan. In general, these causes are to be referred to unnatural practices in the management of children, introduced by superstition, by ignorance, and by foolish notions arising from over-refinement, from prejudice, and from hypothetical systems, while the oeconomy and analogy of Nature, in the conduct and situation of the inferior animals, are almost totally neglected. Every animal, except the human species, brings forth its young without any foreign aid. But incredible numbers of children, as well as of mothers, are daily maimed, enfeebled, and destroyed, by the ignorance and barbarity of midwives and accoucheurs. An infant is no sooner brought into the world than it is crammed with physic. Nature's medicine for cleansing the bowels of infants is the milk of the mother. But midwives absurdly imagine that drugs will answer this purpose much better. All other animals that give suck nurse their own offspring: But we too frequently delegate
this

this tender and endearing office to strange women, whose constitutions, habits of life, and mental dispositions, are often totally different from those of the genuine parent. Infants recently after birth, frequently suffer from giving them, instead of the mother's milk, wine-whey, water-gruel, and similar unnatural kinds of nourishment. In this period of their existence, however, very little food, but a great deal of rest, is necessary for promoting their health, and securing their ease and tranquillity; for infants, when not teased by officious cares, sleep almost continually during several weeks after birth. Young animals are naturally fond of being in the open air; but our infants, particularly in large towns, are almost perpetually shut up in warm apartments, which both relaxes their bodies and enervates their minds. The great agility, strength, and fine proportions of savages, are results of a hardy education, of living much in the open air, and of an unrestrained use of all their organs the moment after they come into the world.

In young animals, as well as in infants, there is a gradual progress, both in bodily and mental powers, from birth to maturity.

These

These powers are unfolded sooner or later, according to the nature and exigencies of particular species. This progress, in man, is very slow. Man acquires not his full stature and strength of body till several years after the age of puberty: And, with regard to his mind, his judgement and other faculties cannot be said to be perfectly ripe before his thirtieth year.

In early infancy, though the impressions received from new objects must be strong, the memory appears to be weak. Many causes may concur in producing this effect. In this period of our existence, almost every object is new, and, of course, ingrosses the whole attention. Hence the idea of any particular object is obliterated by the quick succession and novelty of others, joined to the force with which they act upon the mind. Haller ascribes this want of recollection to a weakness of memory; but it seems rather to proceed from a confusion which necessarily results from the number and strong impressions of new objects. The memory ripens not so much by a gradual increase in the strength of that faculty, as by a diminution in the number and novelty of the objects which solicit attention. In a few years
children

children are enabled to express all their wants and desires. The number of new objects daily diminishes, and the impressions made by those with which they are familiar become comparatively small and uninteresting. Hence their habits of attention, and the ardour of their minds, begin to relax. Instead of a general and undistinguishing gratification of their senses, this is the period when it is necessary to stimulate children, by various artifices, to apply their minds steadily to the examination of particular objects, and to the acquisition of new ideas from more complicated and refined sources of information. The great basis of education is a habit of attention. When this important point is gained, the minds of children may be molded into any form. But that restlessness, and appetite for motion, which Nature, for the wisest purposes, has implanted in the constitution of all young animals, should not be too severely checked. Health and vigour of body are the surest foundations of strength and improvement of mind.

With regard to the duration of infancy, from man to the insect tribes, it seems, in general, to be proportioned, not to the extent of life, but to the sagacity or mental

powers of the different classes of animated beings. The elephant requires 30 years, and the rhinoceros 20, before they come to perfect maturity, and are enabled to multiply their species. But these years mark not the period of infancy; for the animals, in a much shorter time, are capable of procuring their own food, and are totally independent of any aid from their parents. The same remark is applicable to the camel, the horse, the larger apes, &c. Their ages of puberty are four, two and a half, and three years. But in these quadrupeds, the terminations of infancy are much more early. The smaller quadrupeds, as hares, rats, mice, &c. are mature at the end of the first year after birth; and the Guiney pig and rabbit require only five or six months. There is a gradation of mental powers, though not without exceptions, from the larger to the more minute quadrupeds; for the dog and fox, whose sagacity is very great, come to maturity in one year, and their state of infancy is short. But, of all animals, the infancy and helpless condition of men are the most prolonged; and the superiority and ductility of his mind will not be questioned.

The infant state of birds is very short.

Most

Most of the feathered tribes arrive at perfection in less than six months; and their sagacity is comparatively limited.

With regard to fishes, if the whale and seal kind, who suckle their young, be excepted, they receive no aid from their parents. Fishes no sooner escape from the eggs of their mother, than they are in a condition to procure nourishment, and to provide, in some measure, for their own safety. Of the sagacity of fishes, owing to the element in which they live, we have very little knowledge. But their general character is stupidity, joined to a voracious and indiscriminating appetite for food. In opposition to an almost general law of Nature which subsists among other animals, fishes devour, without distinction every smaller or weaker animal, whether it belongs to a different species, or to their own. In animals of a much higher order, voracity of appetite is seldom accompanied with ingenuity or elegance of taste. When the principal attention of an animal is engrossed with any sensual appetite, it is a fair conclusion that the mental powers are weak, because they are chiefly employed upon the grossest of all objects. If this observation be just, fishes must be ranked among

the most stupid animals of equal magnitude and activity.

The infant state of insects is a various and complicated subject. After they escape from the egg, they undergo so many changes, and assume such a variety of forms, that it is difficult to determine the period of their existence which corresponds to the condition of infancy in the larger animals. Different species remain longer or shorter in the form of worms, caterpillars, or grubs, before they are changed into chrysalids, and afterwards into flies. When young, like other animals, they are small and feeble : But, even in their most helpless condition, with a very few exceptions, Nature is their only nurse. They require no aid from their parents, who, in general, are totally unacquainted with their progeny. But, as formerly observed, when treating of instinct, the mothers uniformly deposit their eggs in situations which afford both protection and nourishment to their young. The parent fly, according to the species, invariably, unless restrained by necessity, deposits her eggs upon particular plants, in the bodies of other animals, in the earth, or in water. Whenever, therefore, an insect receives existence in its primary form,
all

all its wants are supplied. Though the mother, after the worms issue from the eggs, takes no charge of her offspring, and frequently does not exist at the time they come forth, yet, by an unerring and pure instinct, she uniformly places them in situations where the young find proper nourishment, and every thing necessary to their feeble condition.

To this general law, by which insects are governed, there are several exceptions. Bees, and some other flies, not only construct nests for their young, but actually feed, and most anxiously protect them.

From what has been said concerning the infancy of animals, one general remark merits attention. Nature has uniformly, though by various modes, provided for the nourishment and preservation of all animated beings while they are in an infantine state. Though the human species continues long in that state, the attachment and solicitude of both parents, instead of abating, in proportion to the time and labour bestowed on their progeny, constantly augment, and commonly remain during life. The reciprocal affection of parents and children is one of the greatest sources of human happiness. If the love of children

dren were not strong, and if it did not increase with time, the labour, the constant attention, the anxiety and fatigue of mothers would be unsufferable. But here Nature, whose wisdom is always conspicuous, makes affection brave every difficulty, and sooth every pain. If a child be sickly, and require uncommon care, the exertions of the mother are wonderfully supported: Pity unites with love; and these two passions become so strong, that hardships, and fatigue of every kind, are suffered with cheerfulness and alacrity.

With regard to the inferior tribes of animals, Nature has not been less provident. To quadrupeds and birds she has given a strong and marked affection for their offspring, as long as paternal care is necessary. But, whenever the young begin to be in a condition to protect and provide for themselves, the attachment of the parents gradually subsides; they become regardless of their offspring, at last banish them with blows, from their presence, and, after that period seem to have no knowledge of the objects which so lately had engrossed all the attention of their minds, and occupied all the industry and labour of their bodies.

bodies.—Here the dignity and superiority of man appears in a conspicuous light. Instead of losing the knowledge of his offspring after they arrive at maturity, his affection expands, and embraces grandchildren, and great-grandchildren, with equal warmth as if they had immediately originated from himself.

CHAPTER VIII.

Of the Growth, and Food, of Animals.

IT is a law of Nature, that all organized bodies, whether animal or vegetable, require food, in order to expand and strengthen their parts when young, and to preserve health and vigour after they have arrived at maturity. The food of animals is digested in the stomach and intestines: By this process it is converted into chyle, and absorbed by the lacteal vessels, in the manner described in Chapter II.——But how this chyle, or nutritious matter, after mingling with the general mass of blood, contributes to the growth, and repairs the waste of animal bodies, is a mystery which probably never will be unfolded by human sagacity. It has, however, like many other secrets of Nature given rise to several ingenious theories and conjectures, some of which shall be slightly mentioned.

Buffon considers the bodies of animals and vegetables as what he calls *internal moulds*. He says, that the matter of nutrition is not applied

applied by juxta-position, but that it penetrates the whole mass; that each part receives and applies those particles only which are peculiar and necessary to its own nature; and that, by this means, the whole parts of the body are gradually and proportionally augmented. This nutritive matter, he remarks, is organic, and similar to the body itself; and hence the size of the body is increased, without any change in its figure or substance. The matter ejected by the different excretions he considers to be a separation of the dead from the vivifying and organic parts of nourishment, which are distributed over the body by an active power: This power, similar to that of gravity, penetrates the internal substance of the body, and attracts the organic particles which are thus pushed on through all its parts. As these organic particles are similar to the body itself, their union with the different parts augments its size, without changing its figure. To unfold an embryo or germ, nothing more is requisite than that it contain, in miniature, a body similar to the species, and be placed in proper circumstances for the acquisition of fresh organic particles to increase its size and unfold its members. Hence nutrition, development,

lopement, and reproduction, are all effects of the same cause.

This account of the nutrition and growth of organic bodies has the appearance of an ingenious theory. But an attentive reader will easily perceive, that it contains no other information, than that animals and vegetables are nourished and grow by the intervention of the nutritious particles of food. This is a fact universally known and admitted. But we are still as ignorant as ever of the mode by which this mysterious operation is performed.

Other authors have supposed that the brain is a large gland; that the nerves distributed over the whole body are the ducts or canals of this gland; and that the principal use of the brain is to secrete nutritious matter, and to transmit it by the nerves to the various parts of the system, in order to expand the different organs of which it is composed, or to repair the waste they may have suffered from labour and other causes.

This theory presupposes that the nerves are tubular, and contain a fluid: But both of these circumstances have hitherto eluded the research of the ablest anatomists. Besides, the learned and indefatigable Doctor Monro,

in

in his *Nervous System*, has rendered it highly improbable that the nerves are the instruments of nutrition. The Doctor reasons in the following manner. On comparing different animals, he remarks, we find no correspondence between the size of their brain, the rapidity of their growth, or the quantity of nourishment they receive. An ox is six times heavier than a man; but the brain of an ox weighs not above a fourth part of that of a man. On this supposition, an ox's brain must secrete twenty-four times more nourishment than a portion equal to it of the human brain. In two years an ox acquires his full size. His brain must, of course, be supposed to transmit daily through the nerves two or three pounds of flesh, bones, &c. But the much larger brain of a man does not, in an equal time, add to his body a fiftieth part of that weight.

‘ In monsters, says the Doctor, ‘ I have
 ‘ found the limbs very plump, though the
 ‘ brain was very small. Nay, in some monsters, the head has been wanting, yet the
 ‘ limbs were as large and perfect as common. In other monsters with one head
 ‘ and two bodies, I have found that the
 ‘ brain furnished the nerves of the head and
 ‘ spinal

‘ spinal marrow on the right side of the
‘ monster; yet the left spinal marrow, at
‘ the top of which there was only a small
‘ medullary knob, about the size of a large
‘ pea, was as perfect as the right one; and
‘ that body, and its limbs, were as large,
‘ and as well nourished, as those on the
‘ right side. On the other hand, where there
‘ were two heads of the ordinary size, and
‘ only one body, the limbs were not remark-
‘ able for their size.

‘ We see that organs, of which the nerves
‘ are so small that we cannot trace them by
‘ dissection, as the bones, the placenta, &c.
‘ grow as quickly as the other organs, in
‘ which the nerves are large and numerous.

‘ A year after I had cut across the sciatic
‘ nerve of a living frog, I could not per-
‘ ceive that limb smaller than the other;
‘ yet it continued to be insensible and mo-
‘ tionless. Nay when, I had broken the
‘ bones of the insensible limb, or wounded
‘ the skin and flesh, I found that the callus
‘ formed, and the wounds healed, as readi-
‘ ly as if the nerve had been entire. The
‘ event was the same after dividing, trans-
‘ versely, the lower or posterior end of the
‘ spinal marrow of the frog.

‘ It

' It is well known,' concludes our author,
 ' that, if powder of madder root is mixed
 ' with the food of a young animal, the bones
 ' become red; or if a bone has been broken,
 ' that the callus joining its parts will be red.
 ' The serum of the blood, in the first place,
 ' is deeply tinged; but the red colour of the
 ' bones is not solely, nor even chiefly, ow-
 ' ing to the coloured serum or blood circu-
 ' lating; for I have found, that, after inject-
 ' ing water into the vessels till these were
 ' emptied of the blood, and that the water
 ' came out colourless, the tinge in the bones
 ' appeared equally deep, and was, therefore,
 ' plainly owing to a great quantity of the red
 ' earth added to the bones in the time of
 ' their growth. But this earth was not
 ' transmitted by the nerves; for the colour
 ' of these, as I found, remained unchanged.'

That the nutritious particles of food are
 conveyed by the arteries, and applied by
 their extremities to the various parts of ani-
 mal bodies which require to be repaired or
 expanded, is an opinion not only best sup-
 ported by facts, but adopted by all the more
 rational physiologists. The principal facts
 and arguments in support of this theory
 shall now be mentioned.

The

The chyle, as formerly remarked, is converted into blood. The glutinous part of the blood, known by the name of *coagulable lymph* resembles the white of an egg. That the white of an egg is the sole nourishment of the chick before its exclusion, is an established fact; and the conclusion, from analogy, that the lymph of blood is destined for the growth and reparation of animal bodies, is by no means unnatural. ‘Without repeating,’ says Dr Monro, ‘our extreme uncertainty as to the tubular nature of the nerves, and the improbability that canals so exceedingly minute as those within the nerves must be, and of such length, are destined for the conveyance of glue, do we not find, that this very matter is separated by the exhalant branches of the arteries of the peritoneum, pleurae, and other shut sacs, and universally, by the branches of the arteries of the cellular membrane?—The kinds of matter necessary for the growth and nourishment of our several organs are so various and different in their nature, that it is altogether incredible they can be furnished by the nerves: Thus, water is needed for the extension of the fore-part of the eye, viscid matter for the crystalline and vitreous

' vitreous humours, earth for the growth of
 ' the bones, &c.; whereas we can as easily
 ' conceive these to be furnished by the arte-
 ' ries, as that, in one place, they should fur-
 ' nish saliva, in another bile, &c.—As the
 ' waste of the several organs is carried off
 ' by the vessels, either circulating for absor-
 ' bent, why should we doubt that the circu-
 ' lating fluids can add a particle in the place
 ' of one that has been carried off, or that an
 ' artery can supply what has been absorbed
 ' by a lymphatic vein? As it is granted that
 ' the secretion of all other kinds of matter
 ' in the bodies of animals is performed by
 ' the branches of the arteries, is it not incre-
 ' dible that there should be an exception to
 ' the general rule in the secretion of the
 ' nourishment? Surely that power which
 ' can convert the food into blood, and can
 ' change blood into bile and saliva, is suffi-
 ' cient to convert it into nourishment.

' I will now add,' continues our author,
 ' that in calli, cicatrices, or accretions, there
 ' are numberless new formed vessels filled,
 ' in the living animal, with red blood,
 ' and which can readily be injected. Nay,
 ' I found by experiment, that such new
 ' formed vessels, produced by the opposite
 ' sides

‘ sides of a wound, unite into continued canals, or anastomose.—If, then, in a callus, new earthy or osseous fibres, and new vessels, can be formed by the original arteries, must we not believe that the waste of this earth, and of these vessels, can be ever after supplied by the arteries which formed them? If so, are we not to conclude, that the waste of other arteries, and of other organs, is supplied in the same manner from the arteries? If the quantity of blood naturally circulating through a limb be diminished, as by tying the trunk of the brachial artery, in the operation for an aneurism, the arm loses part of its strength and size; but the loss is less than, at first sight, might be expected; because the anastomosing (or uniting) canals soon come to be greatly enlarged.

‘ Upon the whole,’ the Doctor concludes, ‘ there are few points in physiology so clear, as, 1. That the arteries prepare, and directly secrete the nourishment in all our organs; and, 2. That the nerves do not contain nor conduct the nourishment, but, by enabling the arteries to act properly, contribute indirectly to nutrition.’

The

The ingenious Charles Bonnet endeavours to shew, that the parts of all organised bodies are contained, in miniature, in germs or buds; that these germs, when placed in proper situations, gradually unfold and increase in magnitude; that the various members of animals and vegetables are expanded, both longitudinally and laterally, by food adapted to their respective natures; and that every germ actually includes the rudiments of the whole animals or vegetables which are to proceed from it during all successive generations.

With regard to vegetables, it is true, that the seed first produces a small tree, which it contained in miniature within its lobes. At the top of this small tree a bud or germ is formed, which contains the shoot or tree that is to spring next season. In the same manner, the small tree of the second year produces a bud which includes a tree for the third year; and this process uniformly goes on as long as the tree continues to vegetate. At the extremity of each branch, buds are likewise formed, which contain, in miniature, trees similar to that of the first year. From these, and similar facts, it is concluded, that all these germs were contain-

ed in the original seed; for the first bud was succeeded by a similar bud, which was not unfolded till the second year, and the third bud was not expanded till the third year; and, of course, the seed may be said to have contained not only the whole buds which would be formed in a hundred years, but all the seeds, and all the individuals, which would successively arrive till the final destruction of the species.

These facts are known and established; but the reasoning deduced from them is fallacious, or, what amounts to the same thing, is perfectly incomprehensible. The seed is unquestionably the origin or cause of all future individuals, which may be infinite. But the idea that it really contained the germs of all the individuals which were to spring from it as a source, is not only absurd, but exceeds all the powers of human imagination to conceive. Theories of this kind, of which there are too many in almost every department of science, hardly merit examination. Every seed, and every animal, according to this doctrine, includes in its own body an infinite posterity! If we assent to reasonings of this kind, we must lose ourselves

felves in the labyrinths of infinity; and, in-
stead of throwing light upon the subject, we
shall involve it in tenfold darknefs. All we
know concerning the nature of growth and
nutrition is extremely limited. We know that,
in the animal kingdom, nutrition is perform-
ed by means of the blood, which is forcibly
propelled through every part of the body by
the action of the heart and arteries; and
that vegetables, in a fimilar manner, are
nourished by the ascension and distribution
of the sap. But, how the nutritive particles
are applied to the various parts of organized
bodies, and how they expand the organs, or
repair their continual waste and loss of sub-
stance, we must content ourselves with re-
maining in perpetual ignorance.

In general, the food of animals, and par-
ticularly of the human species, consists of
animal and vegetable substances, combined
with water or other fluids. The Gentoo, and
some other southern nations, live entirely
upon vegetable diet. From the accounts we
have of the different regions of the earth, it
appears, that the natives of warm climates,
where the cultivation of plants is practised,
employ a greater proportion of vegetable
Z 2 food

food than in the more northern countries. The inhabitants of Lapland have little or no dependence on the fruits of the earth. They neither sow nor reap. They still remain, and, from the nature of their climate, must for ever remain, in the shepherd state. Their comparative riches consist entirely of the number of rein-deer possessed by individuals. Their principal nourishment is derived from the flesh and milk of these animals. In autumn, however, they catch great multitudes of fowls, most of them of the game-kind. With these, while fresh, they not only supply their present wants, but dry and preserve them through the winter. They likewise kill hares, and other animals, which abound in the woods and mountains; but the flesh of the bear is their greatest delicacy. In their lakes and rivers, they have inexhaustible stores of fishes, which, in summer and autumn, they dry in the sun, or in stoves, and in winter they are preserved by the frost. The Laplanders drink water, or animal oils; but never taste bread or salt. They live in a pure air, and have sufficient exercise. Their constitutions are attuned to the coldness of the climate; and they are remarkable for vigour and longevity. The gout, the stone,
the

the rheumatism, and many other diseases which torture the luxurious in milder climes, are totally unknown to them. With the few gifts which Nature has bestowed on them, they remain satisfied, and live happily among their mountains and their flocks. If southern nations afford examples of people who feed nearly on vegetables alone, the Laplanders furnish one of the opposite extreme; for they are almost entirely carnivorous animals.

To Norway, Sweden, Germany, and Britain, the same observation is applicable. In these countries, animal food is much more used than in France, Spain, Italy, Barbary, and the other southern regions of the globe. Many reasons may be assigned for these differences in the food of nations. The natural productions of the earth depend entirely on the climate. In warm climates, the vegetables which grow spontaneously are both more luxuriant and more various. The number and richness of their fruits far exceed those of colder regions. From this circumstance, the natives must be stimulated to use a proportionally greater quantity of vegetable food; and we learn from history, and from travellers, that this is actually the case. In
cold

cold countries, on the contrary, vegetables are not only fewer, but more rigid, and contain less nourishment. The inhabitants, accordingly, are obliged to live principally on animal substances. If we examine the mode of feeding in different nations, it will be found, that, in proportion as men approach or recede from the poles, a greater or less quantity of animal and vegetable substances are used in their diet. Custom, laws, and religious rites, it must be allowed, produce considerable differences in the articles of food, among particular nations, which have no dependence on climate, or the natural productions of the earth. But when men are not fettered or prejudiced by extraneous circumstances, or political institutions, the nature of their food is invariably determined by the climates they inhabit. The variety of food, in any country, is likewise greatly influenced by culture, and by imitation. Commerce occasionally furnishes new species of food, particularly of the vegetable kind. In Scotland, till about the beginning of this century, the common people lived almost entirely upon grain. Since that period, the culture and use of the potatoe, of many species of coleworts, and of fruits, have been intro-

introduced, and universally diffused through the nation.

Whether man was originally intended by Nature to live solely upon animal or vegetable food? is a question which has been much agitated both by the ancients and the moderns. Many facts and circumstances concur in establishing the opinion, that man was designed to be nourished neither by animals nor vegetables solely, but by a mixture of both. Agriculture is an art, the invention of which must depend on a number of fortuitous circumstances. It requires a long succession of ages before savage nations learn this art. They depend entirely for their subsistence upon hunting wild animals, fishing, and such fruits as their country happens spontaneously to produce. This has uniformly been the manner of living among all the savage nations of which we have any proper knowledge; and seems to be a clear proof, that animal food is by no means repugnant to the nature of man. Besides, the surface of the earth, even in the most luxuriant climates, and though assisted by culture, is not capable of producing vegetable food in sufficient quantity to support the human race, after any region of it has become so populous

as Britain, France, and many other nations. The general practice of mankind, when not restrained by prejudice or superstition, of feeding promiscuously on animal and vegetable substances, is a strong indication that man is, partly at least, a carnivorous animal. The Gentoos, though their chief diet be vegetables, afford no proper argument against this reasoning. They are obliged, by their religion, to abstain from the flesh of animals; and they are allowed to use milk, which is a very nourishing animal food. Notwithstanding this indulgence, the Gentoos, in general, are a meagre, sickly, and feeble race. In hot climates, however, a very great proportion of vegetable diet may be used without any bad consequences.

Other arguments, tending to the same conclusion, are derived, not from the customs or practices of particular nations, but from the structure of the human body. All animals which feed upon vegetables alone, as formerly remarked, have stomachs and intestines proportionally larger than those that live solely on animal substances. Man, like the carnivorous tribes, is furnished with cutting and canine teeth, and, like the graminivorous, with a double row of grinders.

The

The dimensions of his stomach and intestines likewise hold a mean proportion between these two tribes of animals, which differ so essentially in their characters and manners.

—From these, and similar arguments, I have no hesitation to conclude, that a promiscuous use of animal and vegetable substances is no deviation from the original nature or destination of mankind, whatever country they may inhabit.

With regard to the different proportions of animal and vegetable food which are most accommodated to the health and vigour of mankind, no general rule can be given that could be applicable to different climates, and to the different constitutions of individuals. Animal food, it is certain, gives vigour to the body, and may be used more liberally by the active and laborious than by those who lead a studious and sedentary life. A great proportion of vegetable food, and particularly of bread, is considered, by the most eminent physicians, as best adapted for men who are fond of science and literature; for full meals of animal food load the stomach, and seldom fail to produce dulness, yawning, indolence, and many diseases which often prove fatal.

The

The remainder of this chapter, from unavoidable causes, must consist of observations of a more desultory kind.

Most animals, when they live long on a particular species of food, are apt to be affected with diseases, which generally arise from costiveness, or its opposite. The guinea-pigs, after being confined for some time to coleworts, contract a looseness, which often terminates in death. But, when those animals are at full liberty, they prevent this effect, by an instinct which teaches them to make frequent changes from moist to dry food: If they are restrained in their choice, they will eat, as a succedaneum, paper, linen, and even woollen cloths.

Though some animals, and many vegetables, would be noxious to man, if used as food, yet, in general, that matter is more regulated by chance and custom than by rational motives. By experience, and the aid of our senses, we acquire a tolerable facility of distinguishing salutary from noxious food. Other animals select their food instinctively; and their choice is chiefly determined by the sense of smelling. The spaniel hunts his prey by the scent; but the grey-hound depends principally upon the use of his eye.

When

When the grey-hound loses sight of a hare, he instantly gives up the chase, and looks keenly around him, but never applies his nose, in order to discover the track. Some rapacious animals, as wolves and ravens, discover carrion at a distance, which, if we were to judge from our own sense of smelling, would appear to be altogether incredible. Others, as eagles, hawks, gulls, &c. surprise us no less by the acuteness of their sight. They perceive, from great heights in the air, mice, small birds, and minute fishes in the water.

One great cause of the diffusion of animals over every part of the globe, is to be derived from the diversity of appetites for particular species of food, implanted by Nature in the different tribes. Some fishes are only to be found in certain latitudes. Some animals inhabit the frigid, others the torrid zones; some frequent deserts, mountains, woods, lakes, and meadows. In their choice of situation, they are uniformly determined to occupy such places as furnish them with food accommodated to their natures. Monkeys, the elephant, and rhinoceros, fix on the torrid zone, because they feed on vegetables which flourish there during the whole year.

The

The rein deer inhabit the cold regions of the north, because these countries produce the greatest quantity of the lichen, a species of moss, which is their beloved food. The pelican makes choice of dry and desert places to lay her eggs. When her young are hatched, she is obliged to bring water to them from great distances. To enable her to perform this necessary office, Nature has provided her with a large sac, which extends from the tip of the under mandible of her bill to the throat, and holds as much water as will supply her brood for several days. This water she pours into the nest to cool her young, to allay their thirst, and to teach them to swim. Lions, tigers, and other rapacious animals, resort to these nests, drink the water, and are said not to injure the young*. The goat ascends the rocky precipice, to crop the leaves of shrubs, and other favourite plants. The sloth and the squirrel feed upon the leaves and the fruit of trees, and are, therefore, furnished with feet which enable them to climb. Water-fowls live upon fishes, insects, and the eggs of fishes. Their bill, neck, wings, legs, and whole struc-

* Amoen. Acad. vol. 2. p. 41.

ture, are nicely fitted for enabling them to catch the food adapted to their natures. Their feeding upon the eggs of fishes accounts for that variety of fishes which are often found in lakes and pools on the tops of hills, and on high grounds remote from the sea and from rivers. The bat and the goat-sucker fly about during the night, when the whole air is filled with moths, and other nocturnal insects. The bear, who acquires a prodigious quantity of fat during the summer, retires to his den, when provisions fail him, in winter. For some months, he receives his sole nourishment from the absorption of the fat which had been previously accumulated in the cellular membrane.

A glutton, brought from Siberia to Dresden, eat every day, says M. Klein, thirty pounds of flesh without being satisfied. This fact indicates an amazing digestive power in so small a quadruped; for the story of his squeezing his sides between two trees, in order to make him disgorge is a mere fable*.

Siberia, Kamtschatka, and the popular regions, are supposed to be the abodes of misery and desolation. They are, it must be allow-

* Gaz. Litteraire, vol. 1. p. 481.

ed, infested with numerous tribes of bears, foxes, gluttons, and other rapacious animals. But it should be considered, that these voracious animals supply the natives with both food and clothing. To elude the attacks of ferocity, and to acquire possession of the skins and carcases of such creatures, the industry and dexterity of savage nations are excited. The furs are demanded by foreigners. The inhabitants by this means learn commerce and the arts of life; and, in the progress of time, bears and wild beasts become the instruments of polishing a barbarous people. Thus, the most substantial good often proceeds from apparent misfortune.

There is hardly a plant that is not rejected as food by some animals, and ardently desired by others. The horse yields the common water-hemlock to the goat, and the cow the long-leaved water-hemlock to the sheep. The goat, again, leaves the aconite, or baneberries, to the horse, &c. Plants which afford proper nourishment to some animals, are by others avoided, because they would not only be hurtful, but even poisonous. Hence no plant is absolutely deleterious to animal life. Poison is only a relative term.

The

The euphorbia, or spurge, so noxious to man, is greedily devoured by some of the insect tribes.

It is a maxim universally received, that every animal, after birth, grows, or acquires an augmentation of size. The spider-fly, however, affords an exception. The mother lays an egg so disproportionally large, that no person, without the aid of experience, could believe it to have been produced by this insect. When the egg is hatched, a fly proceeds from it, which, at the moment of birth, equals the parent in magnitude. Upon a stricter examination of this egg, it has been discovered, that the insect, while in the belly of its mother, undergoes a transformation into the nymph or chrysalis state; and that, instead of a worm, a fly is produced from it, of the same dimensions as the parent. This discovery, however, does not diminish our wonder, that any animal should actually give birth to a substance as large as its own body, and that its size should never afterwards receive any augmentation*.

When caterpillars, some time before their change, are deprived of food, they diminish to at least one half of their former size.

* Reaumur, tom. 6. p. 48. ;—and Bonnet, tom. 3. p. 363.—369.

Their

Their chrysalids, of course, as well as the butterflies which proceed from them, are proportionally small. From this fact we learn the importance of feeding all young animals well till they acquire their full growth.

It is a remark of the ingenious Reaumur, that such insects as feed upon dead carcases, and whose fecundity is great, never attack live animals. The flesh-fly deposits her eggs in the bodies of dead animals, where her progeny receive that nourishment which is best suited to their constitution. But this fly never attempts to lay her eggs in the flesh of sound and living animals. If Nature had determined her to observe the opposite conduct, men, quadrupeds, and birds, would have been dreadfully afflicted by the ravages of this single insect. Lest it might be imagined that the flesh-fly selected dead, instead of live animals, because, in depositing her eggs, she was unable to pierce the skin of the latter, M. de Reaumur made the following experiment, which removed every doubt that might arise on the subject. He carefully pulled off all the feathers from the thigh of a young pigeon, and applied to it a thin slice of beef, in which there were hundreds

of

of maggots. The portion of beef was not sufficient to maintain them above a few hours. He fixed it to the thigh by a bit of gauze; and he prevented the pigeon from moving, by tying its wings and legs. The maggots soon shewed that their present situation was disagreeable to them. Most of them retired from under the slice of beef; and the few that remained perished in a short time. Their death was probably occasioned by the degree of heat in the pigeon's body being greater than their constitution could bear. Upon the same pigeon M. de Reaumur performed another experiment. He took off the skin from its thigh, laid bare the flesh, and applied immediately another slice of beef full of maggots. The animals discovered evident marks of uneasiness; and all of them that remained on the flesh of the pigeon were deprived of life, as in the former experiment, in less than an hour. Thus the degree of heat that is necessary to such worms as inhabit the interior parts of animals, is destructive to those species which Nature has destined to feed upon the flesh of dead animals. Hence the worms sometimes found in ulcerous sores, must belong to a different species from those upon which the above experiments were made.

The growth of some worms, which feed upon animal or vegetable substances, is extremely rapid. Redi remarked, that these creatures, the day after they escaped from the egg, had acquired at least double their former size. At this period he weighed them, and found that each worm weighed seven grains; but that on the day preceding, it required from twenty-five to thirty of them to weigh a single grain. Hence, in about the space of twenty-four hours, each of these worms had become from 155 to 210 times heavier than formerly. This rapidity of growth is remarkable in those maggots which are produced from the eggs of the common flesh-fly.

Before we dismiss this subject, a few observations on that power, inherent in all animal bodies, of dissolving, and converting into chyle, every nutritive substance thrown into the stomach, merit attention.

In order to explain the process of digestion some physicians and philosophers have had recourse to mechanical force, and others to chemical action. The supporters of mechanical force maintained, that the stomachs of all animals comminuted, or broke down into small portions, every species of food, and prepared

prepared it for being converted into chyle. The chemical philosophers, on the contrary, supported the opinion, that the food was dissolved by a fermentation induced by the saliva and gastric juices. The disputes which naturally arose from these seemingly opposite theories, stimulated the inquiries of the ingenious, and produced several curious and important discoveries. Reaumur, M'Bride, Stephens, Spalanzani, Hunter, have all exerted their industry and talents upon this subject. To give even an abridged view of their different labours would be both tedious, and at the same time, would not coincide with the design of this work. I shall therefore confine myself to some results of their experience and labours. Spalanzani, who is a voluminous writer on this subject, relates not only the discoveries of his predecessors, but has enriched his work with numerous experiments and observations made by himself. In his investigation of the process of digestion, and the action of the stomach, he observes the following order :

1. He treats of animals with strong muscular stomachs, as common fowls, turkeys, ducks, geese, pigeons, &c. 2. Of animals with stomachs of an intermediate confis-

tence, as crows, herons, &c. 3. Of animals with membranous stomachs, as frogs, lizards, earth and water snakes, vipers, fishes, sheep, the ox, the horse, the owl, the falcon, the eagle, the cat, the dog, man, &c.

With regard to birds which are furnished with muscular stomachs, or gizzards, Spalanzani, in imitation of Reaumur, procured small glass and metal balls and tubes, perforated with many holes. These he filled with different kinds of food, and forced them down the throats of common fowls, turkeys, &c. He filled balls with barley, or other grains, in their entire state, and allowed them to remain in the stomachs of ducks, turkeys, and other fowls, for twenty-four, and, in some cases, for forty-eight hours. He then killed the animals, took the balls out of their stomachs, and after examining the grains attentively, he could not discover that the gastric juice, to the action of which they were fully exposed by the numerous holes in the balls, had made the smallest impression upon them. They suffered no diminution of size, and exhibited no marks of dissolution. These experiments he often repeated upon a number of fowls provided with muscular stomachs, and the event was

uni-

uniformly the same: In no instance did the gastric juice produce any solvent effect upon the grain contained in the balls. After these unsuccessful attempts, he suspected, that, though the gastric juice was unable to dissolve grains in their entire state, it might act as a menstruum upon them when sufficiently masticated or bruised. To ascertain this point, he afterwards filled his balls with bruised grains, and introduced them into the stomachs of different fowls, as cocks, ducks, turkeys, wood-pigeons, &c. In all the numerous trials he made with bruised grain, he invariably found, that the grain was more or less dissolved in proportion to the time the balls were allowed to remain in the stomach.

Reaumur and Spalanzani, in the course of their experiments upon the digestion of birds with muscular stomachs, discovered a wonderful comminuting force which these stomachs possess. When tin tubes full of grain were thrown into the stomachs of turkeys, and allowed to continue there a considerable time, they were found to be broken, crushed, or distorted, in a most singular manner.

‘ Having found,’ says Spalanzani, ‘ that the
‘ tin tubes which I used for common fowls
‘ were

‘ were incapable of resisting the stomach
‘ of turkeys, and not happening at that time
‘ to be provided with any tin plate of great-
‘ er thickness, I tried to strengthen them,
‘ by foldering to the ends two circular plates
‘ of the same metal, perforated only with
‘ a few holes for the admission of the gastric
‘ fluid. But this contrivance was ineffectu-
‘ al; for after the tubes had been twenty
‘ hours in the stomach of a turkey, the cir-
‘ cular plates were driven in, and some of
‘ the tubes were broken, some compressed,
‘ and some distorted, in the most irregular
‘ manner *.’

The smooth and blunt substances former-ly employed, Spalanzani remarks, though so violently acted upon, could not injure the stomach; he therefore tried what effects would be produced by sharp bodies thrown into the gizzards of fowls. He found that the stomach of a cock, in the space of twenty-four-hours, broke off the angles of a piece of rough jagged glass. Upon examining the gizzard, no wound or laceration appeared. ‘ Twelve strong tin needles,’ says Spalanzani, ‘ were firmly fixed in a ball of
‘ lead, the points projecting about a quarter
‘ of an inch from the surface. Thus armed,

* Spalanzani's *Dissertations*, vol. 1. p. 12.

' it was covered with a case of paper, and
 ' forced down the throat of a turkey. The
 ' bird retained it for a day and a half with-
 ' out shewing the least symptom of uneasi-
 ' ness. Why the stomach should have re-
 ' ceived no injury from so horrid an instru-
 ' ment I cannot explain: The points of the
 ' twelve needles were broken off close to
 ' the surface of the ball, except two or three,
 ' of which the stumps projected a little high-
 ' er.—Two of the points of the needles were
 ' found among the food; the other ten I
 ' could not discover, either in the stomach
 ' or the long track of the intestines; and
 ' therefore concluded, that they had pass-
 ' ed out at the vent †.'

The same author made a second expe-
 riment seemingly still more cruel. He fixed
 twelve small lancets, very sharp both at the
 points and edges, in a similar ball of lead.
 ' The lancets,' says he, ' were such as I use
 ' for the dissection of small animals. The
 ' ball was given to a turkey cock, and left
 ' eight hours in the stomach; at the expira-
 ' tion of which time that organ was opened;
 ' but nothing appeared except the naked ball,
 ' the twelve lancets having been broken to

* Spalanzani's Dissertations, vol. 1. p. 18.

' pieces

‘pieces. I discovered three of them in the
‘large intestines, pointless, and mixed with
‘the excrements; the other nine were miss-
‘ing, and had probably been voided at the
‘vent. The stomach was as found and en-
‘tire as that which had received the needles.
‘Two capons, of which one was subjected to
‘the experiment with the needles, and the
‘other with the lancets, sustained them
‘equally well.’

The small stones so commonly found in
the stomachs of many of the feathered tribes,
have been supposed to sheath the gizzard,
and to enable it to digest, or at least to break
down into small fragments, glass, iron, wood,
stones, and other hard, and even sharp-
pointed substances. Spalanzani has endea-
voured to prove, that the muscular action
of the gizzard is equally powerful, whether
the small stones are present or absent. To
ascertain this point, he took woodpigeons the
moment they escaped from the egg, fed and
nursed them himself till they were able to
peck. ‘They were then,’ continues our au-
thor, ‘confined in a cage, and supplied at
‘first with vetches soaked in warm water,
‘and afterwards in a dry and hard state. In
‘a month after they had begun to peck,
‘hard

'hard bodies, such as tin tubes, glass globules,
 'and fragments of broken glass, were intro-
 'duced with the food. Care was taken that
 'each pigeon should swallow only one of
 'these substances. In two days afterwards
 'they were killed. Not one of the stomachs
 'contained a single pebble; and yet the tubes
 'were bruised and flattened, and the sphe-
 'rules and bits of glass blunted and bro-
 'ken: This happened alike to each body;
 'nor did the smallest laceration appear on
 'the coats of the stomach.' From several
 experiments of a similar nature, and accom-
 panied with the same events, Spalanzani con-
 cludes this subject with that candour which
 is always a genuine characteristic of a real
 philosophic spirit. Upon the whole 'it ap-
 'pears,' says he, 'that these small stones are
 'not at all necessary to the trituration of
 'the firmest food, or the hardest foreign
 'substance, contrary to the opinion of many
 'anatomists and physiologists as well ancient
 'as modern. I will not, however, deny,
 'that, when put in motion by the gastric
 'muscles, they are capable of producing some
 'effect on the contents of the stomach.'

The

The celebrated Mr. John Hunter, in his *Observations on Digestion**, fairly quotes the modest conclusion of Spalanzani. But he insists that stones are extremely useful in the comminution of grain, and other substances, which constitute the food of many fowls. 'In considering,' Mr. Hunter remarks, 'the strength of the gizzard, and its probable effects when compared with the human stomach, it must appear that the gizzard is, in itself, very fit for trituration. We are not, however, to conclude, that stones are entirely useless; for, if we compare the strength of the muscles of the jaws of animals who masticate their food, with those of birds who do not, we shall say, that the parts are well calculated for the purpose of mastication; yet we are not from thence to infer, that the *teeth* in such jaws are useless, even although we have proof that the *gums* do the business when the teeth are gone. If stones are of use, which we may reasonably conclude they are, birds have an advantage over animals having teeth, so far as stones are *always* to be found, while the teeth are not renewed.—If we

* Page 156.

‘ constantly find in an organ substances which
 ‘ can only be subservient to the functions of
 ‘ that organ, should we deny them that use,
 ‘ although the part can do its office without
 ‘ them?—The stones assist in grinding down
 ‘ the grain, and, by separating its parts, allow
 ‘ the gastric juice to come more readily in
 ‘ contact with it.’

The next series of experiments were made upon animals with what Spalanzani denominates intermediate stomachs between the muscular and membranous, as ravens, crows, herons, &c. The power and action of these intermediate stomachs are superior to those of the membranous kind, but greatly inferior to those of the muscular. The tin tubes, or balls, which pigeons and turkeys soon flatten and disfigure, remain unaltered in the stomachs of crows. Their gastric muscles, however, are by no means inert. Though they are unable to compress or distort tin tubes, they are capable of producing this effect upon thin tubes of lead. Birds whose stomachs are of an intermediate kind, with regard to the thickness and strength of their muscular coats, may be denominated *omnivorous*. They eat grass, herbs, grain, and flesh of every kind. When we make experiments

riments upon the digestive powers of gallinaceous birds, the animals must be killed before we can learn what effects have been produced on the substances inclosed in the balls or tubes. But, on crows and ravens, experiments of this kind may be repeated as often as we please, without destroying a single individual. Substances which they are incapable of digesting, as metallic tubes, they have the power of disgorging, or returning by the mouth, in the same manner as falcons, and other birds of prey, throw up the feathers and hair of the animals they have devoured. In birds of prey, this vomiting is commonly performed every twenty-four hours; but, in crows, it happens at least every nine, and not unfrequently every two or three hours.

Spalanzani, as in the former experiments, thrust down perforated tubes, filled with different substances, into the stomachs of crows. These tubes were uniformly thrown up by the animals in a few hours. When the tubes were filled with entire grains, as wheat or beans, he found that the gastric juice, though the tubes, by being repeatedly forced down, continued in the stomach for the space of forty-eight hours, had exerted no solvent power.

power. As the husks of the seeds resisted the action of the gastric juices, he bruised them, and repeated the experiment. ' Four tubes full of this coarse flour,' says he, ' were given to a crow: They remained eight hours in the stomach, and proved the justness of my suspicion; for, upon examining the contents, I found above a fourth part wanting. This could arise from no other cause but solution in the gastric liquor, with which the remainder was fully impregnated. Another observation concurred in proving the same proposition: The largest bits of wheat and bean were evidently much diminished: This must have been owing to the gastric liquor having corroded and dissolved good part of them, as the nitrous acid, diluted with a large quantity of water, gradually consumes calcareous substances. I replaced what remained of the seeds in the tubes, and committed them again to the stomach, wherein they remained, at different intervals, twenty-one hours; at the end of which period they were entirely dissolved; nothing being left but some pieces of husk, and a few inconsiderable fragments of the seeds. Wheat and beans floating loose in the cavity

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‘ ty of the stomach, undergo the same altera-
‘ tion as in the tubes. When I fed my crows
‘ with these seeds, I observed, that, before
‘ they swallowed them, they set them under
‘ their feet, and reduced them to pieces by
‘ repeated strokes of their long and heavy
‘ beaks: And now they digested them very
‘ well; nay, this process was very rapid in
‘ comparison of that which took place with-
‘ in the tubes. But, when the birds, either
‘ from excessive hunger, or violence, swal-
‘ lowed the seeds entire, the greatest part of
‘ them passed out entire at the anus, or were
‘ vomited. We cannot, therefore, be sur-
‘ prised, that the gastric juice could not dis-
‘ solve them within the tubes, since it was
‘ incapable of effecting this process within
‘ the cavity of the stomach, where its solvent
‘ power is far superior.’

Similar experiments were made with French beans, pease, nutkernels, bread, apples, and different kinds of flesh and fish, all of which were dissolved, both in tubes, and in the cavity of the stomach, by the gastric juice.

Spalanzani finishes his experiments on digestion with those animals which have thin membranous stomachs. This class compre-
hends

hends an immense number of species, as man, quadrupeds, fishes, reptiles. In these the coats of the stomach seem to have little or no action upon their contents, the gastric juice being fully sufficient to break down the food, and reduce it to a pulp.

With regard to man, Dr. Stevens, in an Inaugural Dissertation concerning Digestion, published at Edinburgh in the year 1777, made several experiments upon a German, who gained a miserable livelihood by swallowing stones for the amusement of the people. He began this strange practice at the age of seven, and had at that time continued it about twenty years. He swallowed six or eight stones at a time, some of them as large as a pigeon's egg, and passed them in the natural way. Dr. Stevens thought this poor man would be an excellent subject for ascertaining the solvent power of the gastric juice in the human stomach. The Doctor, accordingly, made use of him for this purpose. He made the German swallow a hollow silver sphere, divided into two cavities by a partition, and perforated with a great number of holes, capable of admitting an ordinary needle. Into one of these cavities he put four scruples and a half of raw beef, and into the

the other five scruples of raw bleak. In twenty-one hours the sphere was voided, when the beef had lost a scruple and a half, the fish two scruples. A few days afterwards, the German swallowed the same sphere, which contained in one cavity, four scruples and four grains of raw, and, in the other, four scruples and eight grains of boiled beef. The sphere was returned in forty-three hours: The raw flesh had lost one scruple and two grains, and the boiled one scruple and sixteen grains. Suspecting that, if these substances were divided, the solvent would have a freer access to them, and more of them would be dissolved, Dr. Stevens procured another sphere, with holes large enough to receive a crow's quill. He inclosed some beef in it a little masticated. In thirty-eight hours after it was swallowed, it was voided quite empty. Perceiving how readily the chewed meat was dissolved, he tried whether it would dissolve equally soon without being chewed. With this view he put a scruple and eight grains of pork into one cavity, and the same quantity of cheese into the other. The sphere was retained in the German's stomach and intestines forty-three hours; at the end of which time, not the smallest

smallest quantity of either pork or cheese was to be found in the sphere. He next swallowed the same sphere, which contained, in one partition, some roasted turkey, and some boiled salt herring in the other. The sphere was voided in forty-six hours; but no part of the turkey or herring appeared; for both had been completely dissolved. Having discovered that animal substances, though inclosed in tubes, were easily dissolved by the gastric juice, the Doctor tried whether it would produce the same effect upon vegetables. He, therefore, inclosed an equal quantity of raw parsnep and potatoe in a sphere. After continuing forty-eight hours in the alimentary canal, not a vestige of either remained. Pieces of apple and turnip, both raw and boiled, were dissolved in thirty-six hours.

It is a comfortable circumstance, that no animal, perhaps, except those worms which are hatched in the human intestines, can resist the dissolving power of the gastric juice. Dr. Stevens inclosed live leeches, and earthworms, in different spheres, and made the German swallow them. When the spheres were discharged, the animals were not only

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deprived of life, but completely dissolved, by the operation of this powerful menstruum. Hence, if any live reptile should chance to be swallowed, we have no reason to apprehend any danger from such an accident.

The German left Edinburgh before the Doctor had an opportunity of making a farther progress in his experiments. He therefore had recourse to dogs and ruminating animals. In the course of his trials upon the solvent power in the gastric fluid of dogs, he found that it was capable of dissolving hard bones, and even balls of ivory; but that, in equal times, very little impression was made upon potatoes, parsnep, and other vegetable substances. On the contrary, in the ruminating animals, as the sheep, the ox, &c. he discovered, that their gastric juice speedily dissolved vegetables, but made no impression on beef, mutton, and other animal bodies. From these last experiments, it appears that the different tribes of animals are not less distinguished by their external figure, and by their manners, than by the quality and powers of their gastric juices. Dogs are unable to digest vegetables, and sheep and oxen

oxen cannot digest animal substances. As the gastric juice of the human stomach is capable of dissolving, nearly with equal ease, both animals and vegetables, this circumstance affords a strong, and almost an irresistible, proof, that Nature originally intended man to feed promiscuously upon both.

Live animals, as long as the vital principle remains in them, are not affected by the solvent powers of the stomach. ‘Hence it is,’ Mr. Hunter remarks, ‘that we find animals of various kinds living in the stomach, or even hatched and bred there; but the moment that any of those lose the living principle, they become subject to the digestive powers of the stomach. If it were possible, for example, for a man’s hand to be introduced into the stomach of a living animal, and kept there for some considerable time, it would be found, that the dissolvent powers of the stomach could have no effect upon it: But, if the same hand were separated from the body, and introduced into the same stomach, we should then find, that the stomach would immediately act upon it. Indeed, if this were not the case, we should find that the

B b 2

‘ stomach

‘ stomach itself ought to have been made of
‘ indigestible materials; for, if the living
‘ principle was not capable of preserving ani-
‘ mal substances from undergoing that pro-
‘ cess, the stomach itself would be digested.
‘ But we find, on the contrary, that the sto-
‘ mach, which at one instant, that is, while
‘ possessed of the living principle, was capa-
‘ ble of resisting the digestive powers which
‘ it contained, the next moment, viz. when
‘ deprived of the living principle, is itself
‘ capable of being digested, either by the di-
‘ gestive powers of other stomachs, or by the
‘ remains of that power which it had of di-
‘ gesting other things.’

When bodies are opened some time after death, a considerable aperture is frequently found at the greatest extremity of the stomach. ‘ In these cases,’ says Mr. Hunter, ‘ the contents of the stomach are generally
‘ found loose in the cavity of the abdomen,
‘ about the spleen and diaphragm. In many
‘ subjects, this digestive power extends much
‘ farther than through the stomach. I have
‘ often found, that, after it had dissolved the
‘ stomach at the usual place, the contents of
‘ the stomach had come into contact with
‘ the

the spleen and diaphragm, had partly dissolved the adjacent side of the spleen, and had dissolved the stomach quite through; so that the contents of the stomach were found in the cavity of the thorax, and had even affected the lungs in a small degree.'

CHAPTER IX.

Of the Sexes of Animals and Vegetables.

SECTION I.

Of the Sexes of Animals.

ALL the larger and more perfect animals are distinguished by the sexes of male and female. The bodies of males, though not without exceptions, are, in general, stronger, larger, and more active, than those of the females. In the human species, the male is not only larger than the female, but his muscular fibres are firmer and more compact, and his whole frame indicates a superior strength and robustness of texture. He does not acquire his full growth, and best form, till he arrives at the age of thirty years. But, in women, the parts are rounder, and their muscular fibres more feeble and lax than those of men, and their growth and form are perfect at the age of twenty. A similar observation is applicable to the minds
of

of the two sexes. Man is, comparatively, a bold, generous, and enterprising animal. Women, on the contrary, are timid, jealous, and disposed to actions which require less agility and strength. Hence they are entitled to claim, and, by their amiable weaknesses, they actually receive our protection. Men are endowed with majesty of figure and force of mind; but beauty, and the graces, are the proper characteristics of women. The laxity and softness of their texture may, in some measure, account for the timidity and littleness of their disposition; for, when the bodies of men are relaxed by heat, or by any other cause, their minds become not only timid, but weak, undetermined, and inactive.

The social intercourse of women softens the dispositions, and soothes the cares and labours of the men. Their little female humours, caprices, and follies, give rise to many exertions of virtue. They excite in us compassion, humanity, and tenderness of affection. The delicacy of their bodies, and the weakness of their minds, require our support and protection. In return, the gentle and insinuating manners of the women have a direct tendency to soften and smooth the natural roughness of men. In most governments

ments, women have the entire management and training of children, till their characters and dispositions are almost fixed for life. This is an important office; and would require more education and sense than they commonly receive either from nature or art. But their persevering and unremitting attention to their charge, especially when children are sick or weakly, is so truly astonishing, that no man could have patience to perform the laborious and painful task. Women are likewise said to suffer bodily pain with more resolution than men. Women reason rapidly; but their reasoning, though often acute, is seldom solid.

Modesty is one of the most distinguishing and attractive characteristics of the female sex. This is the great defence with which Nature has armed them against the artifices and deceit of the males. Modesty has a double effect: It both attracts and repels. It heightens the desire of the male, and deters him from rudeness, or improper behaviour. Were women deprived of this amiable quality, all their charms would vanish, and the ardour of love would be extinguished. It is, therefore, not only the interest of females to cultivate modesty, but to guard, with the most

most anxious attention, against the smallest incroachments. Every attack, however apparently insignificant, should be repelled with spirit and intrepidity. To men of sensibility, a single glance of the eye will tell them that their conduct is improper, and make them not only instantly desist, but prevent every future attempt. There is no part of the female character which men revere so much as modesty. It is the brightest and most valuable jewel with which a woman can be adorned. A fine woman without modesty, instead of gaining the affections of men, becomes an object of contempt, and even of disgust. It is equally the interest of men to cherish, and not to injure by indelicacy, a quality from which they derive so much pleasure and advantage.

It is not unworthy of remark, that modesty is by no means confined to the human species. Evident traces of it are discoverable in the brute creation. Even so low as the insect tribes, most females repel the first attacks of the males. If this is not modesty, it has all the effects of it; for it heightens the respect and affection of the males, and makes them employ every alluring art to procure the regard of the female.

It

It is a curious fact, that most carnivorous quadrupeds are more averse from devouring women than men. The bears of Kamtschatka follow the women when gathering wild fruits in the woods, and, though most rapacious animals, do them no farther harm than robbing them of part of the fruit *. The aspect of man being more bold, may, perhaps, create an idea of competition and danger, and excite the ferocity and courage of the animal. There seems to be an instinctive respect, if not dread, of the human kind implanted in most animals. If this be the case, the above fact amounts to a high compliment to the women; for they receive more favour from the brute creation than the men.

With regard to animals, in general, the intercourse of sexes is necessary for the multiplication of the species. But, as formerly remarked †, several of the lower tribes are enabled to multiply without the intervention of sexes. In some animals, both sexes are combined in each individual. The earth-worm, snails, and several shell-fishes, are hermaphrodites; and yet the conjunction of two is necessary for their multiplication.

* Gazette Literaire, vol. 1. p. 482.

† See Chap. 1.

Mr. Adanson, in his Account of Senegal, mentions some shell-animals which, in order to produce, require the union of three individuals. In the polypus, no appearance of sexual distinction has hitherto been discovered. Nature, however, has not denied them the power of multiplication, which is effected in a very singular manner*. Caterpillars of every denomination are totally destitute of sexes, and are incapable, while they remain in that state, of multiplying their species. But, after their transformation into flies, the distinction of sexes is apparent, and their fertility is exceedingly great.

Among the larger animals, the difference of size and figure between males and females is not remarkable. The most striking distinctions arise from the horns, the tusks, the crest, &c. which adorn the head of the male, and are often wanting in the female. But, among the insect tribes, some males differ so greatly from the females, that they have the appearance of belonging to a separate genus. In some butterflies, for example, the female is destitute of wings, while those of the male are very large. The male and female of those animals called *gall-insects* bear

* See Chap. 1.

no proportion to each other, either in size or in figure. They adhere for several months to the stems and branches of plants, shrubs, and trees, without any apparent movement. They have every appearance of galls, being of a spherical or oval figure, from which circumstance they have received their denomination, and were long considered as vegetable substances destitute of every degree of animation. Reaumur, however, by a strict examination of the changes they undergo, and of their internal structure, discovered that they belong to the animal kingdom. He found that they contained thousands of small eggs, and that from these eggs, small animals were produced, which ran about with some quickness, and spread themselves all over the tree or bush. After some days, they attach themselves to the stem and branches, remain immoveable, and gradually increase to their full dimensions, when their bodies are found to contain numbers of eggs. As the perfect animal had no apparent motion, and yet multiplied its species, it was first thought to be an hermaphrodite of a singular kind, and that it was capable of producing without any foreign aid. But Reaumur discovered that they were impregnated
by

by small flies, and that these small flies were male gall insects. The head, the body, the breast, and the six limbs of this fly, are of a deep red colour; and the wings, which are proportionally large, are white, bordered with a band of fine carmine red. In the month of April, he perceived numbers of these flies wandering about on the gall-insects. He observed that they pierced the covering of the gall-insects with a kind of sting shaped like a needle. This circumstance created a suspicion that these flies were the males, and that this was their mode of impregnating the eggs of the female. To ascertain this point, he opened a number of gall-insects, which had no uncommon appearance, and, in some of them, he found the males, in every stage of their existence, till they pierced the external covering, came out in the form of perfect flies, and attached themselves, as usual, to the females. The glow-worm, an animal condemned to crawl perpetually on the surface of the earth, is a female; and the male, instead of a reptile, is a scarabaeus, or beetle, furnished with four wings. A species of phosphorus, emitted from the body of the female, excites the attention of this apparently strange male, who darts

darts down upon her, and actually enables her to continue the kind*. The female of another species of beetle is a perfect reptile, and has not the smallest vestige of wings. But the male is a real beetle with four wings, and is so disproportioned to the female in size, that their junction should appear to be equally singular as that of a ram with an elephant. With regard to the pucerons, or vine-fretters, the males are winged; but the females remain during life totally destitute of wings. In some species of them, however, the females have wings, and these instruments of motion are denied to the males. Between the size of the male and female pucerons, there is likewise a remarkable disproportion. The males, particularly those which have no wings, are so comparatively small, that they run about like the male gall-insects, upon the backs of the females. While this exercise continues, which is often very long, the female remains almost motionless. The more insensibility and listlessness shown by the female, the male exhibits the greater ardour and agility. In this situation he passes whole days without taking any nourishment.

* Reaumur. Oeuvres de Bonnet, tom. 2. p. 87. edit. 8vo.

In birds of prey, the females are larger, stronger, fiercer, and more beautiful than the males. This superiority of strength and magnitude is conferred on the females, because, in general, they are obliged to procure food both for themselves and for their progeny. Vultures, however, are to be excepted; for the males are equal in size, if they do not exceed that of the females. In the gallinaceous tribe of birds, on the contrary, the males are larger, more beautiful, and more courageous, than the females. The peacock, the turkey, the pheasant, and the dunghill cock, are remarkable examples. Dunghill cocks, especially that kind of them which are called *game-cocks*, are the most intrepidly bold and high-spirited animals in the creation. Nothing but absolute death can make them yield to an antagonist. In the domestic state, at least, this intrepidity, and this daring spirit, result from competition, and jealousy of rivals. Game-cocks, to the disgrace of humanity, are fed and trained with the most scrupulous attention. For what purpose? For the cruel amusement and fortuitous emolument of gamblers.

That there are natural hermaphrodites, I have formerly mentioned. But, in man, dogs,

dogs, cats, unnatural hermaphrodites, if they ever exist, are so rare, that the celebrated anatomist, Mr. Hunter, declares he never saw a single example. But, in the horse, the ass, black-cattle, and sheep, he has seen many hermaphrodites. It is said to be a known fact, that, when a cow brings forth two calves, one of them a male, and the other a female, the female is incapable of propagation, but that the male is a perfect animal. In England, a cow-calf brought forth with a bull-calf is denominated a *free-martin*, and is as well known among farmers as either cow or bull. Mr. Hunter remarks, that a cow-calf, brought forth in the situation above mentioned, may be either a free-martin or a perfect female. ‘For,’ he remarks, ‘I have reason to believe, that, in black cattle, such a deviation may be produced without the circumstance of twins; and, even when there are twins, the one a male, the other a female, they may both have the organs of generation perfectly formed*.’ What is called a *free-martin*, or imperfect hermaphrodite, as far as observation has hitherto extended, is confined to black-cattle. The free-martin has all the external charac-

* Hunter’s Observations on the Animal Oeconomy, p. 49.
teristics

teristics of a female calf. When animals of this description are preserved by farmers, it is not for the purpose of propagation, but for yoking with the oxen, or fattening for the table. They neither breed, nor, what is curious, do they discover the smallest inclination for the male, nor does the bull pay the least attention to them.

The free-martin, in figure, resembles the ox, or spayed heifer. It is considerably larger than the bull or cow, and its horns are similar to those of the ox. 'The belly of the free-martin,' says Mr. Hunter, 'is similar to that of an ox, having more resemblance to that of the cow than of the bull. Free-martins are very susceptible of growing fat with food. The flesh, like that of the ox, or spayed heifer, is in common much finer in the fibre than either the bull or cow, and is supposed to exceed that of the ox or heifer in delicacy of flavour and bears a higher price at market*.'

The Romans seem to have had some knowledge of free-martins, though they have not transmitted to us any peculiarities in the structure of these animals. With them, *tau-*

* Hunter's Observations on the Animal Oeconomy, p. 50.

rus was the generic name of the ox kind. They likewise mention *tauræ*, by which, it is thought, they meant barren cows. Columella, when talking of cattle, says, ‘and, like the *tauræ*, which occupy the place of *fertile* cows, should be rejected †.’ Varro likewise informs us, that ‘the cow which is *barren* is called *taura*.’

Mr. Hunter gives an anatomical description of three free-martins, the most perfect of which we shall transcribe.

‘*Mr. Arbuthnot’s Free-Martin**.

‘The external parts were rather smaller than in the cow. The vagina passed on, as in the cow, to the opening of the urethra, and then it began to contract into a small canal, which passed on to the division of the uterus into two horns; each horn passed along the edge of the broad ligament laterally towards the ovaria. At the termination of these horns were placed both the

† Columella, lib. 6. cap. 22.

* ‘This animal was seven years old, had been often yoked with the oxen, at other times went with the cows and bull, but never shewed any desires for either the one or the other.’

‘ovaria

‘ ovaria and the testicles; both were nearly
‘ of the same size, which was about as large
‘ as a small nutmeg. To the ovaria I could
‘ not find any Fallopian tube. To the testi-
‘ cles were vasa deferentia; but they were
‘ imperfect. The left one did not come
‘ near the testicle; the right one came close
‘ to it, but did not terminate in a body call-
‘ ed the epididymis. They were both per-
‘ vious, and opened into the vagina near the
‘ opening of the urethra. On the posterior
‘ surface of the bladder, or between the ute-
‘ rus and bladder, were the two bags, called
‘ *vesiculae seminales* in the male, but much
‘ smaller than what they are in the bull:
‘ The ducts opened along with the vasa de-
‘ ferentia †.’

† Hunter’s Observations on the Animal Oeconomy, p. 52.

SECTION II.

Of the Sexes of Plants.

WHEN an hypothesis, or theory, has obtained a general reception among even the enlightened part of mankind, it is extremely difficult to eradicate the prejudice, either by arguments or by facts. There is not a notion more generally adopted, than that vegetables have the distinction of sexes, and that the influence of what is called the male is indispensibly necessary to the fecundation of the female, or seed-bearing plant: A notion which I have long considered as a striking example of the danger of rashly yielding assent to the alluring seductions of analogical reasoning*.

Every

* The substance of the following facts, and reasonings, was delivered, above twenty years ago, in the Botanic Garden at Edinburgh, in presence of the late worthy and learned Dr Hope, and his students. Dr Hope, in order to excite industry and attention in his pupils, appointed annually four of their number to give a lecture, or discourse upon some botanical subject, which he prescribed to them. To me the Professor assigned the Sexes of Plants, with the liberty of opposing the doctrine of Linnaeus, and his own. Being at that time a very young man, and a strict believer in the sexual

Every person who is acquainted with the sexual theory of vegetables, and with the arguments by which it is defended, must acknowledge, that its principal support is derived from the many beautiful analogies which subsist between plants and animals. Because all animals were supposed to propagate by sexual embraces, and, because plants resembled animals in their growth, their nourishment, their diffemination, and decay, it was therefore concluded, that all vegetables were either male, female, or hermaphrodite; and that sexual commerce was equally necessary for the fecundation of the vegetables of the animal tribes.

This analogy was plausible, and seemed to bestow a splendid uniformity on the conduct of Nature. But experiment, the only test of natural truths, has totally annihilated

sexual system of plants, I willingly undertook the task, because I thought I had the chance of showing some little ingenuity in attempting to shake a theory which I then imagined to be established upon the firmest basis of fact and experiment. But after perusing Linnaeus's works, and many other books on the subject, I was astonished to find, that this theory was supported neither by facts nor arguments, which could produce conviction even in the most prejudiced minds. This discourse was afterwards published in the first edition of the *Encyclopædia Britannica*.

this

this beautiful fabrick. The numberless species of vine-fretters, of polypi, of millepedes, and of infusion animalcules, multiply, without having recourse to the common laws of generation. Here, then, the analogy stops; and, instead of bringing aid to the sexualist, operates powerfully against his favourite hypothesis. If many species of animals are destitute of all the endearments of love, what should induce us to fancy that the oak or the mushroom enjoy these distinguished privileges?

The analogy, besides, is frequently contradicted in the ordinary œconomy of vegetables. It is universally allowed, for example, that, even in oviparous animals, the eggs can only be impregnated while they are in a gelatinous or mere embryo state. When farther advanced, their membranes, or shells, acquire a consistence sufficient to resist the male influence. But, among the vegetable tribes, every circumstance is reversed. In most hermaphrodite plants, (I must speak in the language of the system), the seeds are not only not in a gelatinous state, but have acquired considerable bulk and solidity, long before the pollen, or supposed fecundating dust, is thrown out of its capsules.

The

The same remark is applicable to dioicous plants, or such as are barren and seed-bearing in different individuals. What conclusion is here to be drawn? Analogy fails; and facts contradict the analogy. The pollen of most plants sheds after the seeds of their respective species are far advanced in size and consistence. If this pollen had the power of fecundating, it could seldom impregnate plants of its own species; because, when it is discharged, the seeds are past the proper season; but, by flying promiscuously abroad, this pollen might impregnate different species which happened then to be in a fit condition for the reception of male influence. Consider the consequences of such an arrangement. Is not this to make Nature operate against her own intentions? Nature intends that plants should multiply and perpetuate their kinds; but the sexual hypothesis makes her take the most effectual measures to prevent that intention, and to introduce universal anarchy among the vegetable tribes. Were this theory true, the whole vegetable kingdom, in a few years, would be utterly confounded: Instead of a regular succession of marked species, the earth would be covered

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ed with monstrous productions, which no botanist could either recognise or unravel.

The propagation of plants by suckers, slips, and cuttings, is a curious fact in the history of vegetation. The strawberry is commonly raised by slips taken from the old root, or by suckers sent off from the plant. In either of these methods, the plants flourish, and produce fruit. Many bulbous and eye-rooted plants, and most shrubs and trees, may be propagated in the same manner. Where, it may be asked, do these plants procure impregnation? That they grow, and produce fertile fruit, is undeniable; and yet, according to the sexual hypothesis, the pollen of the male is indispensibly necessary to the ripening and fertilization of the fruit. By means of suckers, slips, cuttings, and layers, the whole globe might be spread over with vegetables, without the possibility of a single impregnation.

Though the argument from analogy should be inconclusive, yet, say the sexualists, we appeal to facts. I shall, therefore, give a short view of the principal facts employed to support the sexual intercourse of plants.

After what has been remarked, it will not be expected that I should mention those parts
of

of Linnaeus's reasoning which are derived from analogy. In many instances, he has pushed analogy so far beyond all decent limits, that it becomes truly ridiculous. For example he gravely tells us, 'That the calix represents the marriage *bed*; the corolla the *curtains*; the filaments the *spermatic vessels*; the antherae the *testes*; the pollen the *male semen*; the stigma the extremity of the *female organ*; the stylus the *vagina*; the germen the *ovarium*; the pericarpium the *impregnated ovarium*; and the seeds the *eggs**.'

The most plausible fact in favour of the sexual hypothesis is derived from the culture of the date-bearing palm-tree. Hasselquist†, and some other travellers, mention their having seen flowering branches of male trees fixed to the females by Arabian gardeners, who alledged, that, unless this operation were performed, their dates would neither be good nor plentiful. This practice can boast of an antiquity long prior to the notion of sexes in plants. How it came to be introduced, it is of little importance to inquire.

* *Sponsalia Plantarum*, in *Amoen*, Acad. vol. 1. p. 103.

† Hasselquist's *Travels*, p. 112. 416. Kempfer. *Amoen*. p. 706. Tournefort *Itag.* p. 69.

We know that the custom is still said to prevail: But we likewise know, that there is not an authentic fact which shows any connection between the *practice* and the *event*, tho' that be an essential ingredient in the controversy. The eastern nations are famous for introducing superstition into every part of their oeconomy; and it is equally difficult to account for their manners as for their culture of palm-trees.

Mylius's letter to Dr. Watson, recorded in the Philosophical Transactions, is an attempt to remove this difficulty, and to show a necessary connection between the male and female palm. Mylius writes to his correspondent, 'That a female palm-tree grew many years in the garden belonging to the Royal Academy at Berlin, without producing any ripe or fertile fruit; that a male branch, with its flowers in full blow, was brought from Leipfic, about twenty German miles from Berlin, and suspended over the female tree. The result was, that the female yielded, the first year, 100 ripe dates. The same experiment being repeated the following year, 2000 ripe fruit were produced.' Not to call Mylius's veracity in question, the experiment is both inconclusive and defective.

fective. Berlin is not the climate of palm-trees. The tree, he informs us, bore flowers and fruit for thirty years before the trial was made; but the fruit, it is said, never came to maturity. Plants seldom produce ripe fruit in a climate not adapted to their nature, until they have grown there a long time. Mylius's palm-tree had carried unripe fruit for thirty years. According to the usual course of exotic plants, therefore, it is natural to think, that, like the American aloe, the tree, during all this time, was making gradual advances towards perfection; that, when the male branch happened to be suspended over the female, the plant had arrived at the highest degree of maturity it could ever acquire in the climate of Berlin; and, of course, that the accidental circumstance of suspending the male branch over it, at this critical period, might give rise to the deception of attributing the ripening of the fruit to the presence of the male branch. The production of 100 ripe fruit only the first year, and 2000 the second, is a strong corroboration of this account of the matter. At any rate, the experiment is exceedingly defective and unsatisfactory. To convince any man that the fertility of this tree

tree was solely owing to some impregnating virtue communicated to it by the male, a branch should have been suspended over the female one year, omitted the next, and so on alternately for a succession of seasons, or, as the sexualists would express it, giving her a husband one year, and denying her that gratification the next. After treating the female in this manner, if it had uniformly happened, that the fruit ripened every year the male branch was suspended, and that none came to maturity when that operation was omitted, then there would have been some foundation for supposing a connection between the ripening of the fruit and the presence of the male branch. But, as this necessary precaution was omitted, the experiment is incomplete, and the conclusion drawn from it precipitate and unphilosophic.

In accounting for the fecundity of all the *dioecious* * and *monoecious* † plants, the sexualists have recourse to the aid of the winds, and of insects. They betake themselves to this strange refuge, in order to explain the

* Plants which have the male character in one individual, and the female in another.

† Plants which have both the male and female characters in the same individual.

manner in which female plants, when situated at a distance from males, are impregnated. Some of them, as Kalm, and others, are perfectly satisfied with this supposed aerial commerce of vegetables, even when the males are ten, fifteen, or twenty miles distant from the females! Here, it may be remarked, that the multiplication of species is one of the most important laws of Nature. All the laws of Nature are fixed, steady, and uniform, in their operation: None of their effects are abandoned to those uncertainties which necessarily result from chance, or from any fortuitous train of circumstances. But, is there any thing, in northern climates at least, more desultory and capricious than the direction and motion of the winds? Can we form a conception of any thing more casual and uncertain than the wayward paths of insects? The very supposition, therefore, that Nature has exposed the fertility of a tenth part of the whole vegetable kingdom, and many of them, too, plants of the utmost importance to man, and other animals, to such accidental causes, is repugnant to every idea of sound philosophy. Besides, the reverse has been proved by Dr. Alston, Camerarius, and Tournefort. These gentlemen reared
female

female plants of the spinage and hemp in such situations, and with such scrupulous precautions, to prevent any supposed impregnation by means of the wind, or of insects, that it is difficult to conceive the possibility of any communication between the males and females. These females, however, produced fertile seeds in the greatest abundance.

Since these experiments were made, it has been discovered, that male flowers are sometimes found lurking on the female plants of the spinage and hemp: And this discovery the sexualists think sufficient to account for the success of Dr. Alston's experiments. But, instead of solving the difficulty, this circumstance seems to involve it in still deeper obscurity: For, that the pollen issuing from the antherae of a male flower or two should rise, fall, and turn round in every direction, so as to light precisely on the stigmata of all the superior, inferior, and circumjacent female flowers, appears to exceed the common powers of human faith. Besides, this circumstance would seem to indicate, that there is no steadiness in what is called *vegetable sexes*. We are even told, that trees, which had continued many years under the character of females, but, from some strange metamorphosis,

morphosis, had suddenly dropped their female forms, and assumed the more robust features peculiar to the male part of the creation!

It was hinted above, that all the dioicous, monoecious, as well as most of the hermaphrodite flowers, being impregnated by means of the wind, seemed not to accord with the rules of philosophizing; we shall now examine that doctrine more closely.

The pollen is allowed to be too large to get admision into the stigmata, though laid upon them with the greatest dexterity. This difficulty the sexualists imagine to be removed, when they tell us, that moisture makes the pollen split, and discharge a subtile aura, and that this aura impregnates the seeds. But, though the pollen should explode by the application of moisture, and discharge a subtile aura, this explosion could never effect the purposes of impregnation: For, when the pollen was lying on the stigma, the aura must necessarily blow off, instead of being absorbed by that part of the plant. Is not the supposition singular, and even contradictory, that a plant should be impregnated by a substance forcibly blown away from the female?

This

This reasoning proceeds upon the admission, that the pollen is laid with dexterity upon the stigma. But it will receive additional force, when I defy all the naturalists in the universe to produce an instance of a single grain of pollen being ever seen on any part of a female plant, even when at no great distance from a male, far less upon the stigmata of each separate flower. Granting, however, the pollen to be carried off from the male by the wind, yet, as the supposed fecundating aura it contains is much lighter than air, and is discharged by the slightest moisture, it can never fall down upon the distant females, but must rise and dissipate in the higher regions of the atmosphere. It may also be discharged by the application of rain or dews before the pollen is carried off by the wind from the male flowers: And, if the winds blow in a direction contrary to the situation of the female plants for a few critical hours, the females must be rendered barren, at least for a season.

It is an established fact, that coleworts, turnips, &c. when growing in gardens, sometimes produce new varieties. These varieties the sexualists uniformly hold up as instances of hybrids, or mongrels, from fortuitous

tous commixtures of different males and females. This conclusion, however, seems to be precipitate. It is well known to nurserymen and gardeners, that, from seeds of the same individual plants, varieties sometimes appear. If these varieties chance to have any qualities superior in value to the original plants, their seeds, shoots, or slips, are collected, and the new kind is propagated with diligence. That the beauty of flowers, and the magnitude and flavour of fruits are improveable by particular modes of culture, and even by unknown accidents, is an undeniable truth: That these improved qualities, in whatever manner procured, continue in the kind, unless allowed to degenerate by negligence, is not less true. But there is nothing so wonderful in these phenomena as to require the most unbounded stretches of fancy to account for them. Are not the beauty, strength, and magnitude of animals, equally improveable by culture? Does not an ox, transported from the comparatively barren mountains of Scotland, to the rich pastures of Yorkshire, assume qualities very different from those he originally possessed? Why, then, should an inconsiderable change in the constitution of a colewort, or a turnip,

excite surprise? Plants are liable to be diversified by numberless accidents. Perpetually fixed to the same local situation, they must receive, indiscriminately, such nourishment as is transmitted to them by the earth and air. When different kinds happen to grow very near each other, and, as they have not the choice of rejecting such food as is presented to them, may not exudations from the one be absorbed by the roots of the other? May not the matter which transpires so copiously from the leaves and flowers of one plant be conveyed to, and absorbed by, those of a different kind? And may not this foreign nourishment occasionally introduce some changes in the colour, texture, or flavour, of the leaves, flowers, or fruit? Nay, is it not reasonable to suppose, that solutions of various mineral substances, the action of particular manures, and a thousand other circumstances, may often induce such changes? Why, then, should we have recourse to unnatural and strained analogies, when the phenomena may be solved upon the principles of sound philosophy?

The learned Dr. Hope, late Professor of Botany in the University of Edinburgh, who was a strenuous supporter of vegetable sexes, thought

thought he had almost established the theory by the following experiment upon the *lychnis dioica*, of which two varieties are natives of Scotland, the one bearing white, and the other red flowers. The Doctor, about twelve years ago, raised a white female and a red male under the same glass-bell, which was sunk so far in the soil as to prevent all communication with other vegetables. The bell terminated in a tube, which, for the occasional introduction of a little fresh air, was stuffed with moss. The seeds of the white female were sown next season; and, instead of white, the plants produced red flowers, in consequence, it was imagined, of the influence of the male upon the female. He likewise asserted, that the red kind, when left to Nature, never brought forth white flowers, nor the white kind red flowers.

Upon this experiment we have to remark, 1. That nothing is more dangerous, or more fallacious in philosophy, than the assumption of general positions without an accurate investigation. The Doctor advanced, for example, that the red and the white *lychnis*, when in a natural state, never change their colours. This position is neither capable of admission nor denial; because no experiment,

nor inquiry, seems ever to have been made on the subject: Yet it is assumed as a premise to the conclusion, that the change of the white into a red lychnis was occasioned by the influence of the red male upon the white female.

2. That hybrids, or mules, uniformly participate of both the species or varieties by which they are engendered. A jack-ass and mare never produce a simple ass or horse, but a mule, or mixture of the two. It should seem, however, that this red lychnis transfused its own individual qualities, without allowing a single particle of the female to appear. This is contrary to every analogy. If the change had originated from sexual commixture, the progeny ought not to have been completely red, but pied, or a mixture of red and white. To whatever cause, therefore, this change may be attributed, it can never be ascribed to any thing analogous to generation.

3. That colour is a delicate and fluctuating quality. It depends so much on light, air, health, and perhaps some unknown causes, that botanists, with great propriety, have rejected it as a specific character. Suspecting that causes of this nature might change

change the colour of the white lychnis under consideration, I examined the condition of some plants then subjected to the same trials in our Botanic Garden. The flowers both of the red and white lychnis were then in full blow under the bell, the glass of which was thick, and of a darker green than our common beer-bottles. The light, of course, transmitted to the plants was lurid and obscure. They were also deprived of a free circulation of air. Under these unnatural circumstances, the plants had a sickly aspect. The flowers of the red variety, instead of a vivid red, were almost perfectly white. Here we have nearly an equal change made upon the same plant, without the possibility of its being effected by the intercourse of sexes. If plants are thus deprived of proper light and air, it cannot be surprising to see changes produced in the colour of their immediate descendants. The contaminated air escaping from the plants themselves, and from the soil under the bell, may be sufficient to produce this effect. I formerly mentioned, that the colour, and other qualities of plants growing near each other, may be changed by absorbing the matter of transpiration and exudation. The argument is applicable with peculiar

peculiar force to plants imprisoned so closely, and having so little access to fresh air. In this situation, they must, of necessity, feed upon each other. Confine a man and a woman for years in a small ill-aired cell, and observe their aspect, and that of their progeny. Their appearance will be very different from that of children produced by healthy parents, and enjoying the benefits of the sun's rays, and of the open air.

4. That, independently of all these arguments, the experiment is incomplete. Even on the supposition of the existence of sexes in plants, the conclusion drawn from it cannot be admitted. The same change, for instance, might have happened, if, instead of a white female and a red male, a white female had been imprisoned with a red female. In this case there could be no commixture of sexes; and yet, it is highly probable, that both would have ripened their seeds, and that these seeds would have produced plants differently coloured from the same varieties growing in a natural state. Till these indispensable parts of the experiment, therefore, be tried, nothing can be concluded in favour of the sexual system.

5. That

5. That flowers growing from the same root, fruits upon the same tree, or raised from seeds of the same individual plant, often vary in colour, size, figure, and texture. These varieties are apparent to the most superficial observers; but they can never, with any degree of propriety, be ascribed to the influence of sex. The causes of such variations are rather to be looked for in the exposure of the plants with regard to light and air, the nature of the soil, the mode of culture, accidental injuries from dews, from electrical, fire, from the poison or wounds of insects, and from the absorption of mineral solutions. In a word, if we are to hope for an explanation of these, and other minute changes in the appearances of plants, recourse must be had to chemical and philosophical principles, and not to an hypothetical commerce of sexes.

The discourse was concluded with the following sentiment:—But I aim not at complete refutation; for experiments are still to be made. I only wish to render the sexual commerce of plants suspicious, that the minds of men may be freed from the fetters of a system, which has, perhaps, too long received the general assent of Europe; and that the
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oeconomy of the vegetable kingdom may again be open to impartial investigation.

To remove the possibility of male influence being conveyed by means of the wind, or of insects, about ten or twelve years ago, I thought, if a female plant could ripen her seeds within doors during the winter, the experiment would infallibly determine the controversy. With this view, I confined a female *lychnis*, which is a native plant of this country, and gave her such a degree of heat as made her produce flowers three months before any male flowers of the same species were blown in Britain. The flowers and the young seed had every appearance of health and vigour. But the plant itself, as usually happens to vegetables when forced to grow in unnatural situations, was feeble, slender, and double the common length it acquires in the fields. I waited the event. My expectations, however, were disappointed; for the flowers dropped long before the seeds were ripened. The plant was kept three years in the same situation; but still the flowers dropped, and no ripe seeds were produced. As the health of plants, like that of animals, depends upon many circumstances, as exposure to the open air, to light, to the

the agitations of the wind, which to them answers the invigorating purpose of exercise, to nocturnal dews, to natural rains, instead of artificial waterings, &c. I resolved to place the female lychnis in a situation where she might enjoy all these advantages, and at the same time be removed from every suspicion of a connection with male influence. For this purpose, I applied to my learned and ingenious friend Dr. Daniel Rutherford, now Professor of Botany in the University of Edinburgh, who, at that time, had a small garden, or rather a little area, in the heart of the city, which was surrounded with houses of five and six stories high, and distant from any male lychnis about an English mile. Dr. Rutherford received this female lychnis into his garden. The first summer after her admission, being enfeebled by her former three years confinement, she dropped her flowers, without producing fertile seeds. During three or four succeeding years, however, she remained in the same situation; and she not only ripened her seeds, but these seeds vegetated, without the possibility of any male impregnation; for the Doctor, after the young plants were in a state of discrimination, uniformly extirpated all the males

males, and never could discover the vestige of a single male upon the female plants. Her female progeny, however, continued to bear fertile seeds for several successive generations. If, after this, and some experiments formerly mentioned, any sexualist chooses to have recourse to the wind, and to insects, he may enjoy his theory; but few men of penetration will join him in opinion.

But, if these facts and reasonings should not be sufficient to convince every believer in the sexual system of plants that the hypothesis has no foundation in Nature, Spalanzani, a late ingenious Italian naturalist, has, by a number of experiments, removed the possibility of any rational doubt on the subject.

Spalanzani, in order to make a complete investigation of this subject, performed a number of experiments on what are called *hermaphrodite*, *monoecious*, and *dioicous* plants.

Hermaphrodite plants comprehend all those which have stamens and pistils, or the male and female organs, in the same flowers. To discover whether the pollen had any influence upon the fertility of the seeds, Spalanzani forced open the petals, or flower-leaves, some time before they began to expand.

pand. He then cut off all the stamina, or male parts, before the supposed foecundating dust was ripe, leaving the female part to its fate. The result was, that, in many of the plants, the seeds did not ripen, or even acquire their full size; in others, they grew to the natural size; but, after being committed to the ground, they did not germinate. Above thirty years ago, a similar set of experiments were made, in the Botanic Garden at Edinburgh, by the late Dr. Alston, the then Professor of Botany. But, whether Dr. Alston's experiments were performed with greater dexterity than those of Spalanzani, it is impossible to determine. The event, however, was the reverse; for Dr. Alston's plants, which were treated in the same manner with those of Spalanzani, not only ripened their seeds, but these seeds, when sown, were found to be as fertile as if no such operation had been performed. But no experiments of this kind can be made with any degree of certainty upon hermaphrodite plants; because they are impracticable, without wounding and injuring the tender flowers. By forcing open the petals some days before they would naturally unfold, the interior parts of the flowers are prematurely exposed to the action
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of the air, of dews, and of the sun's rays. Besides, no man can determine what changes the young seeds may undergo, what injury they may suffer, by an unnatural deprivation of the stamina. In every flower treated in this rough manner, an extravasation of sap must unavoidably be produced. If a pregnant animal is wounded, and in a part too so intimately connected with the foetus, what reason have we to expect a fertile and well-proportioned offspring?

Spalanzani next proceeded to trials on the monoecious plants, or those which bear both male and female flowers separately on the same individual. In spring 1777, he sowed two species of the pumpion, which belong to this division of plants, in a situation removed from every suspicion of foreign connection by means of the wind or of insects. 'In the beginning of June,' says he, 'two individuals, for I had ordered two only to be raised, were just beginning to put forth a few flower-buds towards the bottom of the stalk. At this early period, the male flowers may be easily distinguished from the female. The former, also denominated *barren* by botanists, have a slender stalk; while the stalk of the latter, where it joins
the

‘ the calyx, forms a tumor, consisting of the
‘ immature fruit. I paid daily visits to these
‘ two individuals, and very carefully watch-
‘ ed the progress of both sorts of flowers.
‘ That there might be no suspicion of the
‘ pollen exerting any influence upon the fe-
‘ males, the males were destroyed at their
‘ first appearance. As fruit, when a small
‘ quantity only is left upon a plant, is sooner
‘ ripe, and grows to a larger size, because it
‘ receives a greater quantity of nutritious
‘ juice, I left on each of my two individuals
‘ two flowers only. The buds that made
‘ their appearance afterwards were taken
‘ away, along with the male flowers. Mean-
‘ while my four gourds grew rapidly. Find-
‘ ing that, towards the middle of Septem-
‘ ber, they had attained the usual full size,
‘ I gathered one, in order to inspect the in-
‘ ternal parts. The flesh was too soft, be-
‘ cause the fruit was not thoroughly ripe;
‘ but, in colour, structure, and taste, it re-
‘ sembled fruit produced by plants which
‘ had their male flowers.—The seeds were in
‘ great number, and, as well internally as
‘ externally, were perfectly formed.—At the
‘ end of the month, the other three gourds
‘ were quite ripe. I therefore gathered them,
‘ and

‘ and put the seeds of each into a separate
 ‘ box, that I might be able to examine them
 ‘ at pleasure. The lobes filled the whole in-
 ‘ side of the seeds, and had all the charac-
 ‘ ters of perfect maturity.

‘ Thus far,’ continues our author, ‘ there
 ‘ is a perfect agreement with the observati-
 ‘ ons made on the seeds of some hermaphro-
 ‘ dite plants, which seemed, notwithstand-
 ‘ ing they were deprived of the efficacy of
 ‘ the pollen, to have acquired the same de-
 ‘ gree of perfection as those impregnated in
 ‘ the usual manner. But, as they did not
 ‘ grow, however perfect they might be in
 ‘ appearance, because they had not been vi-
 ‘ vified by the pollen, I imagined, that, for
 ‘ the same reason, the seeds of my three
 ‘ gourds would not grow. It was, however,
 ‘ proper to make the experiment. I there-
 ‘ fore dried one hundred and fifty in the
 ‘ sun, and afterwards planted them in three
 ‘ pots, fifty in each, taken from separate
 ‘ gourds. But the lateness of the season,
 ‘ it being the 10th of October, the constant
 ‘ rain, and the coolness occasioned by it,
 ‘ circumstances unfavourable to vegetation,
 ‘ obliged me to place my pots in a stove,
 ‘ which though it was not heated, was kept
 ‘ warm

‘ warm by a contiguous chimney. *The event*
 ‘ *did not by any means correspond to my expect-*
 ‘ *tation.* I took it for *granted*, that *none* of
 ‘ the seeds would *germinate*; and yet they
 ‘ *almost all came up* very well*.’

Here it is pleasant to observe candour and fair experiment triumphing over deep prejudice. From the above, and many other passages, it is evident that Spalanzani was a keen sexualist, and that he expected his experiments, instead of overthrowing, would confirm his faith; but, like a true philosopher, he candidly, though with reluctance, unhinges his favourite opinion.

‘ I reserved the remainder of the seeds,’ continues Spalanzani, ‘ for another experiment to be made the following spring. Before it can be asserted that fructification has been complete, it is necessary, according to the determination of botanists, not only that the seeds should grow, but that they should also be capable of bringing productive seeds, or, in other words, of perpetuating the species. That I might learn whether the seeds of my three gourds enjoyed this prerogative, I caused some of

* Spalanzani's Dissertations, vol. 2. p. 276. &c.

‘ them

‘ them to be planted in the same place in
‘ May 1778; and, when they were grown to
‘ some size, they were, as in the foregoing
‘ experiment, carefully stripped of all their
‘ male flowers, one female flower only be-
‘ ing left on each individual. These flowers
‘ were furnished with small gourds, which
‘ grew ripe towards the beginning of autumn,
‘ and the seeds they produced grew just as
‘ well as the former*.’

With regard to dioicous plants, or those which produce male flowers on one individual and female flowers on another, they are by far the most unexceptionable subjects for determining the existence or non-existence of sexes in plants. Accordingly, Bonnet, Fourgeroux, and Spalanzani, &c. about the year 1770, placed female plants of this description in situations so strictly guarded against the possibility of foecundating dust being conveyed to the females either by the air or by insects, that the supposition of male influence baffles all the powers of imagination. These females, however, uniformly produced ripe seeds; and these seeds were as prolific as if they had been surrounded with males.

* Spalanzani's Dissertations, vol. 2. p. 278.

From the facts and arguments above related, and many others which might be adduced, it appears, that this beautiful theory, derived from a mistaken analogy, has no foundation in Nature. I would not have dwelt so long on this subject, if I had not sincerely wished that the minds of men might be emancipated from the fetters of a system which has too long received the almost universal assent of the literary world; and that the oeconomy of the vegetable kingdom may again be open to impartial inquiries.

END OF THE FIRST VOLUME.

